# LEGAL MEDICINE

R. B. H. GRADWOHL

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Edited by

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# PREFACE

Many books on legal medicine have been written in the German, French, Italian, and English languages. Some are classics. Many are now outdated and out of print. The fundamental subjects that were considered in these older books were pathological anatomy and toxicology. Legal medicine has far outgrown these two considerations. While these remain firm pillars, other supporting columns have since been added to strengthen the modern structure.

The planning of the programs of the annual conferences of the newly founded American Academy of Forensic Sciences convinced the Editor of this volume (the founder and first President of the Academy) that a textbook utilizing the subject matter of these various meetings might well accomplish the making of an up-to-date textbook. With that end in view, the Editor selected a group of authors who, he felt, could well give their views and experiences in making up a reliable and trustworthy book. Even with this plan, the last word has not yet been written because of the rapidly changing pictures that are developing in law-science relationships. We do hope, however, that those who need such a book—medical and law students, members of the medical and legal professions, jurists, law enforcement officers, pathologists, and toxicologists—will find here exact information on these various aspects of legal medicine.

Most appropriately, Sir Sydney Smith, of Edinburgh University, Scotland, Dean of the Faculty of Medicine and Professor of Forensic Medicine, was selected to discuss the history of legal medicine. Sir Sydney Smith, who might well be termed the Nestor of legal medicine in the British Isles, hardly needs an introduction at our hands because he is well known for his almost limitless knowledge of the literature of legal medicine—a renowned teacher, a contributor to journal and textbook literature—a leader in his field; his chapter constitutes a complete history of this subject.

The medicolegal autopsy requires special and detailed treatment. To this end, Dr. Frederick Newbarr, Chief Autopsy Physician to the Coroner of Los Angeles, and his associate, Dr. Richard Myers, discuss it fully and succinctly.

Dr. Louis J. Regan, Counsel to the Los Angeles County Medical Society, has written a chapter on the legal authorization for autopsies. This, we believe, will be very useful information to our readers.

Professor Elwyn L. Cady, Jr., Lecturer in Law-Medicine Relations, University of Kansas City School of Law, gives an excellent synopsis of laws relating to medical practice.

Dr. George S. Strassmann, Pathologist to the Metropolitan State Hospital, Waltham, Massachusetts, a former professor of legal pathology in Germany, has written very fully on forensic thanatology, postmortem changes, vital reactions,

effects of high and low temperature and electric currents, mechanical asphyxia, pathological findings in poisonings, and pregnancy and abortion.

L. R. Janes, M.A., M.B., Pathologist, the Royal Sussex County Hospital, Brighton, England, who has performed over many years numerous medicolegal autopsies, discusses the common causes of unexpected deaths. This is one of the most important chapters in the book.

Wounds of the head and body and their interpretation are considered in Chapter 9 by Francis S. Camps, M.D., Lecturer in Forensic Medicine, the London Hospital, London, England. This covers very completely incidents relative to this type of trauma.

From the standpoint of the physical anthropologist, Dr. T. D. Stewart, Curator of Physical Anthropology, United States National Museum, Washington, D. C., has given the principal points relative to evaluation of evidence from a study of the skeleton.

Dr. David B. Scott, Dental Surgeon, United States Public Health Service, Bethesda, Maryland, has given the latest views on dental science in identification and criminology.

Dr. W. E. Evans, an eminent pathologist of the Charing Cross Hospital, London, devotes a chapter to a thorough discussion of the examination of hairs and fibers.

Dr. R. B. H. Gradwohl, Director of the Police Laboratory of the St. Louis Police Department, has written four chapters: one on blood identification, another on the proof of nonpaternity by blood tests, a third on examination of seminal fluid, and a fourth on infanticide. Dr. Alexander S. Wiener has very kindly read and approved both manuscript and galley of the chapter on proof of nonpaternity.

Mr. Sidney B. Schatkin, Assistant Corporation Counsel for the City of New York, also has written on paternity proceedings and blood tests. Mr. Schatkin has had a wide experience in court and has a rare understanding of both the legal and the scientific phases of this subject.

Dr. John J. Connor, Chief Autopsy Physician of the Coroner of St. Louis, Missouri, has written the chapter on rape.

Owing to the frequent discussion of abortion and the law, Dr. Louis J. Regan, of Los Angeles, California, has discussed the laws of the United States on these points.

Dr. Jesse Lawrence Carr, Clinical Professor of Pathology, Clinical Professor of Legal Medicine, and Director of the Department of Legal Medicine, University of California at San Francisco, discusses sudden death in infants. A very important aspect of this subject deserved a special chapter at the hands of Dr. M. David Orrahood, Instructor in Pathology, St. Louis University School of Medicine, and Associate Pathologist, St. Louis City Coroner, who gives an interesting review of the medicolegal aspects of septal pneumonia in infants.

One of the most important aspects of legal medicine is the subject of toxicology and microanalysis. This very extensive chapter has been handled by Mr. Sidney Kaye, Toxicologist to the Chief Medical Examiner, Richmond, Virginia, and Dr. Leo Goldbaum, Toxicologist, Army Medical Center, Walter Reed Hospital, both highly trained and experienced toxicologists.

In another chapter, Dr. William V. Eisenberg, Chief, Micro-analytical Branch, Division of Microbiology, U. S. Food and Drug Administration, Washington, D. C., discusses the microscopic-crystallographic procedures for the identification of drugs.

Recent advances in the treatment of poisonings are discussed by Dr. A. W. Freireich, Assistant Clinical Professor of Medicine, Post-Graduate Medical School, New York University, and Toxicologist, Office of Chief Medical Examiner, Nassau County, New York. This is a very practical and complete story of the numerous advances that have been made in this department.

Alcohol has become a subject of increasing importance in textbooks on legal medicine, especially in view of the importance of alcohol in the blood of the alleged drunken driver. Dr. C. W. Muehlberger, Toxicologist, of the Michigan Department of Health, Lansing, Michigan, a renowned American authority, discusses this fact fully.

The medicolegal aspects of workmen's compensation are taken up by Mr. Edmund Thomas, Chief Counsel, Industrial Accident Commission of California, San Francisco, California.

There is no subject in legal medicine more interesting and more important than forensic psychiatry. Dr. Val B. Satterfield, Assistant Professor of Clinical Psychiatry, Washington University School of Medicine, and Consulting Psychiatrist to the St. Louis Metropolitan Police Department, discusses this in a most thorough and original manner. Immediately following that chapter is one by Professor Elwyn L. Cady, Jr., on the legal relations of the mentally ill.

A textbook on legal medicine would hardly be complete without a review of the legal aspects of neuropathology. This chapter was written by Dr. Cyril B. Courville, Consultant in Neuropathology, Coroner's Office, Los Angeles County, and Director, Ramon Cajal Laboratory of Neuropathology, Los Angeles County General Hospital, and one of the nation's leading neuropathologists.

One of the modern weapons in the investigation of crime is lie detection. This is discussed by Dr. Herbert P. Lyle, Coroner, Hamilton County, Ohio, an authority on this subject. Further, narcoanalysis for criminal investigation is handled by Dr. James H. Matthews, Clinical Instructor in Anesthesiology, University of Minnesota Hospitals, Minneapolis, Minnesota.

In the development of scientific crime detection, there has been a remarkable development in the United States of the police laboratory. Mr. Clemens Maise, Associate Director of the St. Louis Police Laboratory, gives an outline of police laboratory administration.

Mr. Clark Sellers, a well-known authority on questioned documents, of Los Angeles, California, discusses very broadly the question of expert testimony. This subject is further embellished by the chapter by Dr. E. M. Hammes, Clinical Professor Emeritus of Neurology and Psychiatry, the University of Minnesota Medical School, on the so-called "Minnesota Plan" of expert testimony.

Frequently in court arises the question of where trauma and disease overlap. An eminent member of the St. Louis Bar, Mr. J. L. London, discusses this question.

The final chapter of the book is by the Editor on official medicolegal investigations in the United States.

As intimated before, no one can write the last word on the subject of legal medicine, but it is hoped that the collected thoughts of so many outstanding authorities will go very far to bring the reader of this book, whether he be a pathologist, a toxicologist, a practicing physician, a law enforcement officer, a lawyer, or a teacher, well to the front in an understanding of these problems. The book is offered in the hope that it will be a worth-while contribution of this highly diversified and important subject, legal medicine.

R. B. H. G.

St. Louis, Mo.

# CHAPTER 2

# SPECIAL ASPECTS AND PRACTICAL CONSIDERATIONS OF THE MEDICOLEGAL AUTOPSY

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AND

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This discussion of the medicolegal autopsy is approached with considerable ambivalence of feeling. It is our firm opinion that this highly specialized procedure should, under ideal conditions, be undertaken only by the experienced medicolegal pathologist. Yet as realists we know, and surveys have shown, that most of the medicolegal examinations outside of the few metropolitan centers in this country are done by persons without postgraduate training or any extensive practical experience in medicine as applied to the problems of law and justice.[1] The following quotation from an English medicolegal work published in 1823 despite the ponderous style is applicable to this present condition in the United States:

> "But it has been demanded, and in a tone, as it would seem, suggested by the feelings of mortified pride and disappointment, how it can have happened that in Britain, a country distinguished above all others for the unceasing jealousy and circumspection with which every thing that even remotely interests the life and comfort of the subject is scrupulously regarded, a science so peculiarly calculated to control the disorders of the social system, to rescue innocence from infamy or death, and to lead to the detection and punishment of crime, should for so long a period have been imperfectly appreciated, and utterly neglected?"[2]

Despite encouraging indications of quickening interest within both the medical and the legal professions concerning the present deplorable state of this practical specialty, it will be a matter of years before sufficient training facilities will be available, even assuming that an adequate number of physicians can be persuaded to make legal medicine a full-time career. With this in mind the present discussion is intended primarily for the medical student and the physician who must occasionally perform an autopsy with medicolegal aspects in the course of his present or future practice. In any event, such persons should firmly insist that expert consultation be obtained at least in important and unusual cases. If this help is not available, or if the responsible authorities

persist in the archaic attitude that any licensed physician is qualified to act as "autopsy surgeon," then there is an obligation to learn enough to avoid the irreversible destruction of the objective evidence of the autopsy and to prevent the formulation of erroneous and unsound opinions on the basis of such data. This will explain the numerous negative admonitions in the following pages which, however, are in no manner intended in a scolding sense. The study of many autopsy protocols and transcripts of court proceedings has shown us the necessity for such an approach if major tragedies and miscarriages of justice are to be avoided. The experienced medicolegal expert will find little that is new to him but may find interesting the approach and method of operation in a large and busy coroner's office processing about four thousand medicolegal autopsies a year.

Hospital pathologists occupy an intermediate position in relation to forensic medicine. Their knowledge and experience are of great advantage in furthering the meticulousness and thoroughness of the examination and in interpreting and correlating the multiple, if sometimes minor, pathological changes observed in most dead bodies. The trend now apparent in this part of the country for coroners without full-time professional staffs to utilize local pathologists is quite encouraging. As the number of trained pathologists continues to increase, it is to be hoped that more of them can find time to assist in this important work. However, even these men must understand the peculiar problems and objectives of legal medicine if the desired information is to be obtained. Moritz[3] in his succinct style has summarized the problem in this regard:

> "Several weeks ago a State's attorney came to see me, bringing with him the report of an autopsy that an experienced hospital pathologist had performed on the body of a man dead of a bullet wound. Murder was suspected but the suspect claimed that he had fired in self-defense. There were no witnesses. The State's attorney had expected difficulty in getting at the facts and had accordingly prevailed upon the coroner to engage the services of the best pathologist in the region for the performance of the autopsy.
>
> "The report ran to 12 pages and on the first page were listed 17 pathological diagnoses. Among other things, the dead man was found to have a healed non-deforming rheumatic aortic and mitral valvulitis, an accessory ostium of the right coronary artery, a healed pyelonephritis, a horseshoe kidney, and parenchymatous degeneration of the liver and kidneys. Two penetrating wounds of the scalp, one frontal and the other occipital, were recorded. It was stated that these were connected by a cylindrical blood filled tract passing through the intervening skull, meninges and brain.
>
> "The State's attorney said rather plaintively that the pathologist had ovbiously expended a great deal of effort in the examination, that science was undoubtedly benefited by the disclosure of such interesting conditions as parenchymatous degeneration and healed pyelonephritis, but that he wanted to know (1) had the bullet that killed the man been fired from behind or in front, (2) had the gun been held close to or at a distance from the victim's head at the moment of firing, (3) were there any traces of metal along the tract of the wound that might show whether it had been produced by a lead or by a jacketed

bullet, (4) had the victim been immediately incapacitated by the wound or might he have walked as far as a dozen steps after being wounded, (5) did the now-buried body disclose certain cutaneous scars and blemishes or dental pecularities that would indicate whether or not he had been correctly identified, and (6) had the victim been drunk at the time he received the fatal injury.

"I read the entire report with care, including the weights and measurements of all of the viscera, but failed to find the answers to any of the questions that the attorney had raised. So far as he was concerned, the expert pathologist had contributed no more relevant information from his investigation than had been obtained at a glance by the first police officer who saw the body. Not only had the County obtained no further evidence bearing on the guilt of the suspect but it actually had spent in the neighborhood of $200 to hire a pathologist who destroyed most of the evidence that may have been present.

"The trouble was that this doctor, who was undoubtedly competent in the field of hospital pathology, did not know the objectives of the medico-legal autopsy. He did not know the importance of making a detailed study of a variety of conditions that are of medico-legal rather than of conventional medical interest."

The great Virchow was himself guilty on occasion of shortcomings in this respect. In a published report of a post-mortem examination requiring two and three-quarters hours for completion and necessitating a report many paragraphs in length, there is a brief and only fairly adequate description of a suicidal gunshot wound of the head—in this particular instance the essential thing.[4a]

In the Coroner's Office of Los Angeles County it has been found fairly satisfactory to require that the autopsy surgeons have two years' recent experience in pathology in an approved hospital, medical school laboratory, or public agency, following the customary year of internship. These men then are given intensive on-the-job training in practical forensic pathology before they are allowed to assume full responsibility for their own assigned cases. Reports of examinations continue to be reviewed and checked within twenty-four hours of completion by a senior member of the staff. He may direct further procedures or examinations to be undertaken. Unfortunately, financial considerations and limited opportunities for professional advancement sometimes lessen zeal and necessitate auxiliary interests and practice, but it is required that forensic pathology remain the primary and major interest of the staff members.

Some of the earliest dissections of the human body recorded in the western world were undertaken with medicolegal objectives, and in this sense the growth of modern anatomical knowledge began because of legal medicine. The first well-authenticated medicolegal autopsy was performed in Bologna in northern Italy in 1302. The examiner was Bartolomea de Variagiana (died 1318), who was assisted by another physician and three surgeons. The subject was a nobleman supposed to have died of poisoning, and the decision of the committee of experts appointed by the court is reported to have been against poisoning as the cause of death. Another surgeon of Bologna, William of Saliceto (about 1201-1280), is supposed to have performed at least one medicolegal post-mortem at an earlier date. Bologna had long been the seat of a famous law school, which

factor may have stimulated such investigations. Perhaps the lawyers, who have a direct professional and often financial interest in medicolegal matters, should take a more active part in the improvement of medicolegal coverage in our day. Prior to and for some time after these early full-scale forensic autopsies it was the custom in medieval Europe for medical men to make external examinations of wounds with a view of stating which were mortal. This procedure must have been somewhat similar to the still all-too-prevalent "inspection" of bodies of those dying violent deaths. The legal codes promulgated by George, Bishop of Bamberg, in 1507 and by Charles V in 1530 and 1533 (*Constitutio Criminalis Carolina*) directed that medical experts were to be employed in the investigation of violent deaths and suspected infanticides, abortions, and medical malpractice. "Serious examination and, if necessary, opening of the body" were authorized. Ambroise Paré performed the first medicolegal autopsy in Paris in 1562, and from that time the practice became more common in France and in the Germanic countries. It was not until the latter half of the fifteenth century that the Florentine physicians, Benivieni and Tornius, applied for permission to examine bodies in order to explain obscure cases and to advance medical knowledge.[5,6,7a,8,9]

Usually no written consent from the next of kin is required to permit the opening of a body for medicolegal purposes, as is necessary when such examinations are undertaken for purely academic reasons. However, the case must under the local laws be one over which the coroner or medical examiner has jurisdiction; otherwise the physician may find himself in the uncomfortable position of having performed an unauthorized autopsy.[10] In this situation civil liability may be incurred, and in many jurisdictions criminal responsibility also arises. Malpractice coverage may be denied by insurance companies if unlawful autopsy is a criminal act under the existing laws, since it is against public policy to insure a person against liability resulting from a criminal act. In a Missouri case it was also ruled that while the physician was protected under the terms of his policy concerning inquests and autopsies while acting as the physician, he was not protected when acting as a public official—in this instance as coroner.[11,12] Therefore, the medical man who does medicolegal work either in the capacity of coroner, medical examiner, or as the authorized agent of these officials will be well advised to have a thorough knowledge of what deaths are legally subjected to official scrutiny and of the extent of examination allowed under the laws of the particular locality in which he functions. If the statutes are obscure or inadequate, the medicolegal expert should be sufficiently interested to suggest and promote changes and clarification by the duly constituted authorities or legislative bodies.

Inspection of the body as it is found either at the scene of the alleged crime or in some other place to which it has been transported before discovery is properly preliminary to any but the most routine and clear-cut medicolegal autopsy. In many localities and in Los Angeles County it is not the practice for either the Coroner himself or for the autopsy surgeon to go to the place where the dead body is discovered. This part of the investigation is left to the law enforcement officers who submit written reports of their investigations to the Coroner. We

have found that frequent orientation lectures to police officers give them a better understanding of our problems and of the type of information required, with resultant improvement in the usefulness of their reports. We do not hesitate to request supplemental investigation as often as necessary with specific questions in view. Close contact is maintained with the detectives who are assigned to obscure cases, and very satisfactory relations result once the police officers understand that we have only the avowed purpose of providing sound medical opinion and objective medical evidence for the use of all interested parties to a case. Much valuable information may be obtained by the autopsy surgeon if even at a time later than the discovery of the deceased, he questions persons present at the time of death or relatives concerning the medical history. He should discuss the case with any attending physician since this part of the investigation necessarily will be of a technical nature. It may be noted that in Los Angeles County about 60 per cent of coroner's cases are sudden or unexpected natural deaths without any element of criminality. The desirability of examining the position and condition of the dead body in relation to the surroundings in which discovered is indisputable—if not by the autopsy surgeon himself, at least by a trained medical investigator. The authors regret that, due to the inherited system and geographic considerations prevailing in their jurisdictional area, they are not qualified to write at first hand concerning this phase of the investigation. Brief introductory discussions in this connection will be found in the books and articles of Gonzales, Vance, and Helpern[13]; Helpern[14]; Renshaw[15]; and Simpson.[16] The only fairly detailed and readily available work in English by a medical man is the standard work of LeMoyne Snyder.[17a] Otherwise, this information is widely scattered in the numerous texts and journal articles in the fields of police science, forensic chemistry, scientific criminology, and criminal investigation. Certainly the physician should not officiously undertake this phase of medicolegal work without some preliminary experience and training in a center where such is the practice. Otherwise he will sometimes do much harm in destroying evidence and will in the process engender much ill will on the part of assigned law enforcement officials. Ill-considered opinions at this point may set in motion prolonged and expensive but needless criminal investigation.

Even though he does not examine the body before it is transferred to the morgue, the forensic pathologist should insist that he be given the opportunity to make a thorough examination before clothing is removed or, particularly, before any part of the body is washed. This will usually be possible whatever administrative regulations govern the outside investigation at the scene. Of course, the expert or his associates must be sufficiently interested to be "on call" and to respond promptly when summoned. It is at this point that objective physical evidence associated with, but not necessarily an integral part of, the body must be collected and properly preserved (Fig. 1). The medical man will be fortunate if the expert criminologist or forensic chemist associated with most progressive police departments is present to assist at this stage of the examination. Suggestions and discussion will be of inestimable mutual benefit. If the

physician works alone, it is his obligation to have sufficient knowledge properly to collect, pack, and label this delicate material unless it is to be hopelessly distorted or perhaps forever lost.

Great care is necessary in the removal of clothing in order that traces of dust, dirt, glass, paint fragments, or other foreign materials are not shaken out and lost. Any such material loosened in the course of undressing the body should be carefully scraped up with a scalpel or spatula and placed in small transparent envelopes of cellophane or similar material. Transparent envelopes are more satisfactory for the preservation of such material since ready visibility lessens the amount of manipulation when they come to be studied in the crime laboratory. Others recommend collecting such material in filter paper, which is folded and stored in pillboxes. Obviously contamination with extraneous material is to be avoided. Many bullet wounds are inflicted through clothing, and the underlying skin will give only incomplete information concerning the wound.


Fig. 1.—The importance of preserving minute fragments of foreign material associated with the dead body. *A*, A small splinter under the fingernail. *B*, The same splinter enlarged. This splinter was later connected with the murder weapon.

Unburned powder flecks adhering to the clothing may be lost with rough manipulation or unnecessary handling of these articles. These flecks are to be carefully removed with the aid of forceps and a magnifying glass and preserved in glass vials. Do not cut through bullet holes, tears, or knife holes; rather cut around them if necessary to facilitate removal. Above all do not stick fingers, pencils, or probes through openings; the direction of distortion of fibers may later be of extreme importance in deciding which is the entrance and which is the exit of a bullet. Spent bullets lying loose in the clothing may be overlooked or lost down

the sewer. The shoe soles may show entrance or exit marks which will be of value in investigating deaths by electrocution.

The character and distribution of bloodstains on clothing should not be altered or distorted. Bloodstained clothing should be hung up and dried at room temperature before packing, otherwise moist stains may putrefy, which will interfere with subsequent laboratory tests. Too frequently clothing is forcefully removed and carelessly piled in a corner of the autopsy room. Loose folding of garments with clean paper laid between the folds is the proper method of packing. Generally folds should not pass through suspected seminal stains since the spermatozoa may be damaged. The garment is then wrapped in clean wrapping paper and properly labeled. Tight rolling or stuffing into paper bags is to be avoided.

Certain biological specimens must also be taken at the time of autopsy. Fluorided blood, taken as will be described subsequently, or clotted blood must be retained for possible blood typing. Hair, to include not only head and pubic hair but also beard hair, hair from the eyebrows, eyelashes, axillary hair, and body hair, should be plucked out and not cut. These samples are preserved separately in properly identified cellophane envelopes. Fingernails should be clipped rather than scraped, and the right and left clippings should be preserved in separate envelopes.

Vaginal smears to be studied for spermatozoa should be taken as soon as possible. They are indicated in all cases of homicide involving a female whether or not sexual assault appears at the time to play a role in the case. A long pipette with a rubber bulb, a cotton swab or a spoon curette with a dull edge are useful in this connection. If fluid is obtained from the vaginal tract, smears should be prepared and air dried immediately while the remainder of the fluid is preserved in a tightly stoppered vial or test tube. This same fluid, if taken before embalming, can be employed for the determination of the acid phosphatase level.

Foreign material present in the wounds is carefully lifted or scraped away with a scalpel and is preserved as recommended previously. Washing is to be avoided and air drying before packaging is desirable. If the material is difficult to remove, the whole wound and surrounding tissues may be excised and submitted for study. Preservation in 10 per cent formalin is permissible if study will be delayed. The cardinal rule, however, is: *Do not probe, scrape, enlarge, cut into, excise, or otherwise distort or destroy any wound until it has been completely measured, charted, and photographed!*

There are never too many photographs in connection with a medicolegal autopsy. Identification photographs are necessary but are not alone sufficient. Close-up pictures of significant injuries and wounds are invaluable later after the body has long been buried or cremated. This is particularly true of wounds with a distinctive pattern such as may be caused by claw hammers, meat tenderizers, threaded pipes, or distinctive automobile ornaments. A small ruler should be placed in these close-up photographs so that relative size can be determined. Color photography is highly desirable, particularly since some of the types of color film can now be developed without return to the maker with resultant disruption of the chain of possession. The sequential color photographs taken by

Dr. Richard Ford of Harvard University showing each step in the medicolegal investigation are strong arguments in favor of color photography to supplement, if not replace, black and white prints. Lantern slides in black and white or color greatly facilitate presentation of the medical evidence in the course of a trial.

The techniques employed in the actual performance of the medicolegal autopsy do not differ essentially from those of general pathology. We have found a modified Virchow technique, i.e., removal and examination of each organ separately, most practical for thorough study when a large number of examinations must be done in a limited time. Certainly it is the best method when physical facilities are less than ideal. Others may prefer one of the evisceration techniques attributed to Zenker,[18] Letulle,[19] or Ghon.[20] Methods of this type are sometimes credited to Rokitansky, but this is erroneous since the Rokitansky procedure as published by his pupil, Chiari,[21] involves in principle the dissection of the viscera while still in place and undisturbed within the body cavities. This technique somewhat modified is often useful in forensic practice. The chief prerequisite is sufficient judgment and experience to modify a standardized procedure as demanded by the circumstances of the specific case and to preserve relationships between organs until study is complete. Certainly no experienced operator would remove the thoracic viscera separately before a stab wound of the chest had been thoroughly investigated. In infants the thoracic viscera are best removed as a unit if, for instance, congenital cardiac defects are to be described and classified. The lengthy and minutely detailed regulations governing medicolegal examinations as promulgated, at least until recently, in the central European states could scarcely find ready acceptance in a country where the individual is trained to think and act independently. Some of these official directives even specified the exact instruments to be carried and the condition in which they were to be kept! One feature of these regulations, namely, the provisions for review of protocols and medicolegal opinions by a higher authority such as the staff of a university institute, has much to recommend it.[4b]

Under the best circumstances the autopsy should be performed before embalming. This necessitates either examination soon after death or a system for refrigerated storage of bodies until a more convenient time. Embalming early in the post-mortem state is so widely practiced in this country, and adequate refrigeration facilitates are so often lacking, that it must be accepted that many cases will be modified by the embalmer's attentions before reaching the autopsy room. Furthermore, there is in many communities a definite problem of public relations with the undertakers as well as with surviving families. By way of compromise we function under a system of embalming before autopsy so modified as to allow for maximum accuracy under the conditions prevailing. It is not presented as the best system but is probably the best workable solution if embalming is routinely permitted before post-mortem examination. Further discussion necessitates that the physician have some understanding of the fundamentals of the embalming process.

The embalmer will first shave the face and close the eyes and mouth. Plastic shells are placed beneath the eyelids and may be removed readily for later examination of the eyeball, but the mouth is usually closed by sewing the alveolar

ridges or wiring the teeth together. Therefore wounds of the lips, mouth, or tongue and the dental status must be thoroughly investigated before this step is taken. Arterial embalming is the next procedure. This involves exposure of a major artery (usually the carotid, axillary, or femoral) and the concomitant vein. Two cannulae, one directed upward and one directed downward in the arterial lumen, are inserted. A long cannula with a plunger to break up blood clot or a pair of long thumb forceps are employed to hold open the vein. Embalming fluid under a pressure of about 5 to 7 pounds per square inch provided either by a mechanical pump or by gravity is then injected into the arterial cannulae. About 5 gallons of diluted embalming fluid will be run through the average body, passing through the circulatory system from arterial to venous side and out the open vein. The conduct of this part of the process is empirical and is terminated when discolorations are removed and the tissues feel sufficiently firm and fixed. The solutions, which are diluted for use, are patented products and the exact compositions are seldom known except to the manufacturer.[22] One type of fluid known as "preinjection" contains esters or glycols of various types but little or no formaldehyde; this fluid is supposed to dissolve blood clot and promote flow of the embalming fluid through the circulatory system. It does not appear to be particularly effective in the first respect and does not, in our experience, disturb ante-mortem thrombi. Later injection is carried out with "arterial fluid" composed of formaldehyde, ethyl alcohol, glycerin or glycols, phenolic compounds (usually not carbolic acid), and various inorganic salts to prevent hemolysis and discoloration of the tissues. These inorganic salts include sodium chloride, nitrates, borax, benzoic or salicylic acids, and salicylates. Pink or red dyes are also added in order to impart a more lifelike color to the tissues. Methyl alcohol may be present in varying quantities, but arsenic salts and mercuric chloride are now forbidden by law. Special medicolegal fluids free of ethyl alcohol and phenols can also be obtained. Areas which have not received sufficient embalming fluid via the circulatory system may be injected hypodermically, and sometimes embalming fluid is poured into the mouth and may get into the lungs or stomach by this direct route.

The second major step, the so-called "cavity work," consists of inserting a long sharp trocar through the abdominal wall, and by means of suction and multiple punctures through the abdominal and thoracic viscera removing fluid contents. Finally about a pint of what amounts essentially to concentrated formaldehyde solution is forced through the trocar into the body cavities. Partially decomposed, burned, or severely mangled bodies may be packed by the embalmer in cotton soaked with strong cavity solution. This solution is irritant to the eyes and air passages and may be quite annoying if prolonged examination of such a body is necessary.

Previously autopsied cases which must be reopened will generally have "hardening compound" placed in the body cavities. This appears to consist of sawdust, infusorial earth, or plasterlike compounds saturated with formaldehyde or containing solid paraformaldehyde. Not infrequently viscera and hardening compound are adherent in a firm, sticky, mortarlike mass which is separable with patience and running water, although the end result is usually far from satisfactory.

Only arterial embalming should knowingly be allowed before autopsy, and even this is to be forbidden in certain types of medicolegal cases. Air embolism will be undemonstrable in the embalmed body. Obviously, the important post-mortem phenomena of rigor, livor, cooling, and the progression of decomposition cannot be evaluated in the irrigated and partially preserved body. Blood without oxalate or fluoride must be taken from the right and left heart chambers for the Gettler chloride test and for magnesium levels if drowning is a possible factor.[13b,23] Blood must be obtained from the left heart for glucose levels because a sample from the right side may show an abnormally high level due to release of glucose by the liver.[24] Vaginal smears for spermatozoa are not significantly affected by embalming. It is impossible to evaluate blood distribution in the organs after embalming because of the irrigation of the circulatory system. Since embalming is usually done soon after death, autolytic changes in the kidney or other parenchymatous organs may be somewhat retarded by what amounts to partial fixation by perfusion; thus microscopic study actually may be facilitated. Post-mortem changes in the superficial mucosa of the gastrointestinal tract are only slightly retarded. Another undesirable feature is the increased firmness and the hardening of the tissues, which renders the removal of the organs mechanically more difficult, particularly the removal of the internal genitals in the female and of the organs of the neck. No body should be embalmed without specific clearance from a responsible professional person after he has reviewed the history and has sufficient knowledge of the circumstances to be reasonably certain that embalming will not hopelessly interfere with determination of the cause of death.

Embalming does not entirely preclude bacteriologic studies as logically might be expected. Smears from the meninges, lungs, tracheobronchial tree, or other sites may be prepared and examined in the usual way. Weed and Bagenstoss[25] have recently reported culture studies in twenty-five bodies embalmed from three to sixty hours. From twenty-two of the cases *Mycobacterium tuberculosis* was cultured. Other organisms isolated included *Escherichia coli*, *Klebsiella pneumoniae*, *Micrococcus pyogenes*, *Pseudomonas aeruginosa*, *Proteus vulgaris*, *Hemophilus influenzae*, various species of streptococci, as well as *Nocardia asteroides*, and *Histoplasma capsulatum*. We have isolated a pure culture of hemolytic streptococcus from the body of an infant embalmed twenty-four hours. This information indicates that embalmed tissues should be handled with the same precautions against infection as practiced with untreated tissues. Also it is quite apparent that bacteriologic studies should be attempted even after embalming. The external surfaces of the viscera are to be considered as contaminated and should be seared with a hot knife. Cultures are taken with glass tubes drawn out to a capillary point or with the inoculating wire or loop plunged deep into the underlying tissue. Alternately pieces of tissue taken with aseptic technique may be minced and diluted with saline to give approximately a 10 per cent emulsion of tissue, which is used as the inoculum. Virus studies on embalmed tissues would be of pertinent interest. At any rate, embalming fluid does not appear to be as highly germicidal as the chemical content would indicate; and penetration of the tissues, even in histologically vascular areas, is far from complete.

Cavity embalming should never be permitted before opening of the body. The trocar punctures of the viscera are confusing and have on occasion been misinterpreted as ante-mortem wounds. In such circumstances sections of suspected wounds must be examined microscopically for evidence of vital reaction. The concentrated cavity fluid hardens and bleaches the external surfaces of the solid viscera and also alters the inner surfaces of the hollow viscera. The irritant fumes add to the difficulties. In addition, contents of the gastrointestinal tract are spilled into the cavities and are lost by suctioning away. We have, however, in several cases been able to salvage as much as 100 c.c. of stomach contents still in the gastric lumen after multiple perforations by the trocar.

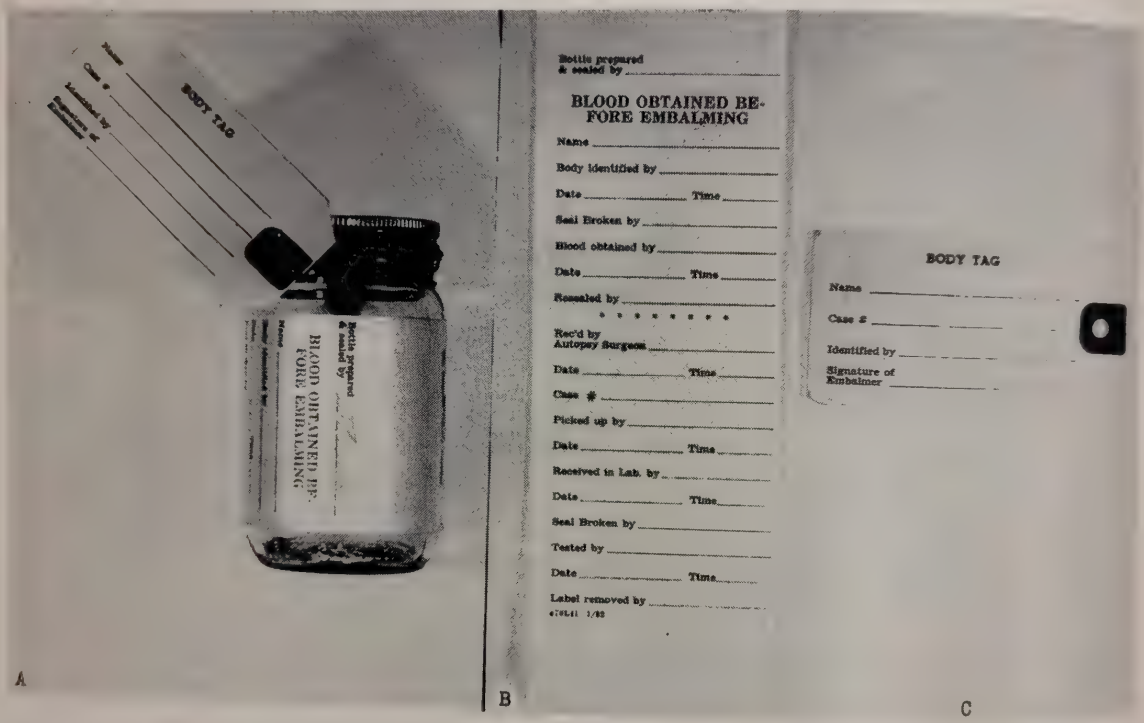


**Fig. 2.—*A*, Blood specimen bottle containing sodium fluoride as issued for use. *B*, Detail of the blood bottle label. *C*, Detail of tag affixed to body at the time blood specimen is obtained.**

The problem of toxicologic analysis of tissues from the embalmed body is difficult but with certain expedients and compromises is not insurmountable. Obviously arterial embalming as outlined above will make it impossible to recover or to report accurately most volatile compounds; cyanide particularly reacts with the formaldehyde present. The only solution is to demand a specimen of unembalmed blood in *every* case. We employ for this purpose an 8 ounce, wide mouth, screw cap container of the mayonnaise jar type (Fig. 2,*A*). About 0.5 gram of sodium fluoride is added as an anticoagulant and preservative. Sodium fluoride will satisfactorily preserve blood for at least two weeks without refrigeration and for at least four weeks with refrigeration. In our experience blood alcohol determinations done on fluorided blood under these conditions have shown a drop in the alcohol level of less than one point in the second decimal place. Screw cap must be tight, and the bottles must be chemically clean when

issued. New caps are supplied if the bottles are reused. The bottles are issued by the laboratory with a self-sealing cellulose band in place.*

If all embalming is performed in a central mortuary, it is necessary that the embalmer break the seal, obtain the blood specimen, label it correctly, reseal the bottle, and submit the specimen to the autopsy surgeon who conveys it directly to the laboratory. If embalming is done by various persons in scattered locations, the chain of evidence is more difficult to maintain intact and a careful record must be kept of every person handling the bottle. Specimen label (Fig. 2, *B*) indicates the type of information necessary. These steps may be summarized as follows:

*Laboratory*

1. Prepare bottle
2. Seal
3. Initial
4. Fasten body tag to bottle

*Mortuary*

1. Remove body tag from bottle, fill out and attach to body
2. Check instruments for contamination
3. Break seal
4. Take specimen
5. Reseal

*Autopsy Surgeon*

1. Remove body tag from body and attach to bottle
2. Check information on body tag with information on bottle label
3. Fill out information on label

*Messenger*

1. Fill in time and date picked up and delivered on bottle label

*Laboratory*

1. Fill in information on label
2. Break seal
3. Make test
4. Remove label from bottle and file with medical report

The tag described (Fig. 2, *C*) is filled out and placed on the great toe of the body at the time of embalming and is not removed until the pathologist begins the autopsy.

A supply of new cellulose seals is kept on hand in every preparation room where coroner's cases are embalmed. A not infrequent source of difficulty is contamination of the sample by the agent, usually a cresolic germicide, used to disinfect the embalming instruments, and personnel concerned must be instructed concerning the necessity for clean instruments. The practice of starting the flow of fluid into the arterial system in order to force blood out of the vein into the bottle is unallowable since in practice it is almost impossible to avoid contamination of the specimen by embalming fluid. Persistent attention to detail and the instruction of new embalmers together with routine checking for contamina-

*Obtainable from Sylvania Division, American Viscose Corporation, Fredericksburg, Virginia.

tion of all blood specimens, whether needed for analysis or not, are necessary for the success of such a program. The administrative officials concerned must understand the problem and must take disciplinary action in cases of carelessness or deliberate neglect.

Blood may be unobtainable if the body is crushed or if the remains are fragmentary. In such instances embalming is not permissible before examination and unembalmed brain tissue must be obtained or blood free in the cavities such as the thorax may be retained for analysis. Toxicologic findings in embalmed tissues must be interpreted with some caution because the amount of poison present may be altered by the irrigation and washing out of blood and fluid which are inherent to the embalming process. The hardening and fixing of the organs also renders extraction more difficult and perhaps less complete. In our experience, however, acceptable figures and interpretations can be made in cases of poisoning by the mineral acids, alkalis, alkaloids, heavy metals, barbiturates, carbon monoxide, carbon tetrachloride (especially in body fat), ergot, fluorides, oxalic acid, phosphorus, and silica among the more common poisonous agents. Opium alkaloids may give some trouble if color tests dependent upon the phenolic grouping are used, and we have generally found urine more satisfactory than tissue for the detection of drugs in this group. Chloral hydrate is water soluble and a considerable amount may be washed out during embalming; however, in cases of poisoning by this agent large quantities are usually ingested and can be recovered either in the tissues or in the stomach, but it is necessary to employ a reaction which is not interfered with by formaldehyde. Barbiturate levels demonstrated in the parenchymatous organs compare very closely to those reported generally in the literature. Carbon monoxide has been demonstrated in fluid expressed from the spleen several weeks after embalming. New compounds are a problem until suitable techniques, often excluding color tests, can be discovered in the literature or developed independently.

Theoretically some of the volatile compounds could be detected in embalmed tissues if a sample of the same preserving fluid were available for analysis. For example, the absence of ethyl alcohol in the embalmed brain would be significant in the absence of ethyl alcohol in the preservative solution; if the test were positive, the chemical problem would become more complex and the chemical evidence would be difficult to substantiate without equivocations and stipulations. Only extreme emergency justifies such an analysis.

The following summary of changes in the gross appearance of organs and tissues is based upon personal experience with several thousand arterially embalmed bodies. Saphir[26] differs on some minor points and should also be consulted.

**Central Nervous System.**—Amount of fluid in the subarachnoid space is generally increased. Meninges are unaffected. Brain is partially hardened, which facilitates removal. Extradural, subdural, and subarachnoid hemorrhages are not notably affected except for slight hardening of the clot. Amount of fluid in old subdural hematomas is not increased. Intracerebral hemorrhages and brain tumors are well preserved. Cerebral contusions are well demarcated. Lack of partial fixation in a localized area or involving a whole hemisphere is helpful in demonstrating vascular occlusive lesions. Spinal cord is generally partially fixed and somewhat preserved.

**Circulatory System.**—No reliable idea of blood distribution within the viscera can be obtained. Generally areas supplied by vessels occluded from one cause or another are incompletely or entirely unaffected by the embalming fluid. If large vessels have been injured, embalming fluid may collect in the body cavities and render difficult an exact opinion as to the amount of blood lost. Coagulated embalmed blood may be mistaken for thrombi, particularly in the heart chambers and in the pulmonary arteries (check microscopically). Emboli in the pulmonary artery are not washed out, dissolved, or disrupted. Intima of arteries may be discolored red or pink either by hemoglobin pigments or by pink dye in the embalming fluid. Early myocardial infarcts are obscured but can be confirmed microscopically. Older myocardial infarcts and myocardial scarring are well demarcated and well preserved. Lack of embalming over an area supplied by a coronary artery suggests occlusion of the artery. Coronary atherosclerosis and thrombi in the coronary arteries are generally undisturbed. Valvular changes and vegetations are not notably affected. Fluid in the pericardial sac is not appreciably increased; a small amount of blood may be present due to small perforations in the superior vena cava occurring during embalming. Do not mistake this for cardiac tamponade.

**Lungs.**—Volume of fluid in the thoracic cavities may be slightly increased. Lungs generally are heavy and wet, but this is variable depending upon the amount of fluid which circulates through the lungs. Dry lungs are also observed. Some idea of the degree of pulmonary edema and congestion can be obtained. Bronchopneumonic foci are sometimes apparent to palpation and usually are granular, slightly elevated, and somewhat different in color from the surrounding lung tissue. Purulent material can still be expressed from the cut surfaces of pneumonic foci. Lobar pneumonia is not notably affected by embalming. Infarcts usually are well demarcated and are unembalmed. Pulmonary fibrosis, silicosis, and tuberculosis are not notably altered. The tracheobronchial tree and contents and the larynx are undisturbed.

**Liver.**—Generally the liver is somewhat increased in firmness and is rather pale, but embalming is patchy and is generally best at the periphery. The surface is often mottled yellowish red because of uneven irrigation and fixation. Chronic passive congestion is still quite apparent. Portal cirrhosis is well preserved; however, increased firmness may delay the diagnosis of hepatic necrosis until the microscopic sections are studied. Fatty livers are readily recognized.

**Gall Bladder and Bile Ducts.**—Gall bladder and bile ducts are not altered.

**Spleen, Lymph Nodes, and Bone Marrow.**—Generally the spleen is well embalmed and the pulp throughout is firm, making evaluation of the consistency difficult. The prominence of the follicles is not affected by embalming. Lymph nodes show variable degrees of increased firmness. The bone marrow is not significantly preserved by embalming.

**Gastrointestinal System.**—Esophagus is generally well preserved. A small amount of embalming fluid will be present in the gastric contents and confusion may result from color changes due to pink dye in the fluid. The gastric mucosa is moderately well preserved, although, microscopically, the superficial mucosa will show autolytic changes unless autopsy takes place soon after death. The mucosa of the small bowel and the mucosa of the large bowel also show only moderate preservation and undergo autolysis in the superficial zones. Autolysis of the pancreas, both grossly and microscopically, is appreciably delayed.

**Endocrine System.**—Cortical and medullary areas of the adrenals are generally well preserved. Medullary hemorrhage is not affected. Thyroid substance is pale and moderately increased in firmness. Pituitary is slightly preserved and hardened, which somewhat facilitates removal. Thymus is only moderately increased in firmness.

**Urinary System.**—Kidneys are well preserved, firm, and slightly more pale than usual. Pelves and ureters are not affected. A small amount of embalming fluid is generally present in the bladder contents, but this does not appreciably increase the volume of urine. Bladder mucosa is only fairly well preserved.

**Genital System.**—Testes and prostate are unaffected. Hydrocele fluid is not increased in amount. Scrotal hematomas may increase in volume if a large vessel has been opened by the antecedent injury. Uterus, tubes, and ovaries are only slightly hardened. Endometrium is slightly preserved. The contents of the endometrial cavity, such as products of conception or fluid containing foreign materials resulting from abortion, are not significantly altered.

**External Injuries.**—In the first twelve hours bruises retain fairly well the color present at the time of death. After this time early bruises tend to darken slightly and assume a reddish-blue or slate-gray color. The contrast to the surrounding pale embalmed skin is marked. Bruises which were old at the time of death show fair retention of natural color even forty-eight hours after embalming. After forty-eight hours or so, all bruises tend to assume a uniform muddy brown-red hue. Abrasions dry and become dark yellowish brown and parchmentlike. If washing and tampering with wounds is forbidden, study is generally satisfactory; but fluid may run out of penetrating wounds during embalming. As a rule, ecchymoses and subcutaneous effusions of blood do not increase appreciably in size. Periorbital tissues are an exception and very often swell. If a large vessel is injured in relation to any effusion of blood subcutaneously, increase in size may take place due to the flow of embalming fluid into the area.

Embalming is of positive advantage in the study of exhumed bodies since preservation may be truly remarkable even after two or three years in the ground. Unfortunately, the process of embalming is not uniform and the degree of preservation is unpredictable in the individual case. This also applies to recently embalmed bodies; then, too, variable degrees of post-mortem change may have occurred before embalming was performed.

None but those with official business should view the medicolegal autopsy. The celebrated case of William Palmer, the poisoner, is one in point. Palmer was a doctor and was allowed to be present while the body of one of his victims was examined. He made very obvious and partially successful attempts to upset the container with the stomach contents.[27] Furthermore, there may arise civil liability in connection with the outraged feelings of the surviving family if the autopsy is conducted for the delectation of the idle curious. The local laws must be observed regarding the attendance of properly appointed representatives of the family, the parties to a litigation, or an accused person. Medicolegal cases are frequently of the type in which newspaper reporters are interested. However, above all do not allow newspaper men to be present during the examination. Do not give them opinions or statements other than designatedly preliminary ones until the work on the case is completed and final decisions have been reached. To avoid misquotation it may be desirable to prepare a short written statement accurately setting down the facts to be distributed to representatives of all the papers at the same time.

Identity of the deceased person should be established, whenever possible, preliminary to further procedures. Frequently papers or documents found in the clothing will answer the question and will supply the names of relatives or friends

who can view the remains and settle the matter. Such identification by witness is very essential in criminal cases when legal proceedings are to be expected. Local practice varies, but usually this identification must be made in the presence of the coroner, medical examiner, or a responsible deputy. In noncriminal cases examiners should at least insist upon direct identification by the person having custody of the corpse in order to protect against examination of the wrong body. Tags attached to the toe of the body as described previously are useful in this regard. Fingerprints should be taken routinely in all cases and filed with the case record. Remember that designing persons have not infrequently claimed bodies for burial in order to perpetrate frauds of various types.

Further steps are necessary if these simple expedients do not establish identity. Clothing, jewelry, and personal effects should be carefully sorted, described, and preserved. Photographs of such quality as to present a reasonable likeness of the person must be made. Height, weight, color of hair and eyes, apparent age, physical peculiarities, tattoos, old injuries, operative scars, and peculiar occupational stigma must all be noted. Grooming and cleanliness of the body may indicate social status. Most important of all is an accurate record of the teeth. A supply of standard dental diagrams should be at hand, and the forensic pathologist should learn the accepted methods of charting teeth and artificial dental appliances. Dentists are very cooperative in assisting with difficult or important cases or in the event of catastrophes leaving many unidentified dead. Height is readily measured and weight should be determined with scales; if these figures must be estimated, a note should be made to that effect. Hair may be curled, dyed, or bleached, and artificial hair goods may be present. An artificial pad in the hair was useful in identifying one of our cases. Artificial eyes should not be described as "normal." Tattoos lend themselves well to photographic preservation. Casper[28] reported long ago that even faded tattoo marks left a trace of cinnabar or other pigment in the regional lymph nodes. The peculiar physical evidences of occupation have recently been collected and illustrated in a valuable reference work by Ronchese.[29] All of these factors are also applicable in varying degree to the identification of decomposed, sodden, or burned bodies and will be mentioned again in the appropriate sections.

It is in the nature and extent of the external examination that the medicolegal autopsy differs most significantly from its academic counterpart. A few sentences will be adequate to cover this phase of the examination in the latter instance, whereas in violent or unnatural deaths the external examination may be more important than the rest of the autopsy combined. This external examination should be completed before the body cavities are opened, otherwise relations of the surface tissues to the viscera and particularly the relationship of surface wounds to the deeper tissues will be disturbed. Turning and manipulating the body for thorough external inspection is also untidy when the cavities are open. The general description of the external characteristics, as suggested under identification, is also a part of the autopsy protocol even though identity has been established. Of course, detailed dental charts are not necessary in routine cases. Character and distribution of any stains are noted. Inspection of the hands, including the folds between the fingers, should be painstaking.

The post-mortem phenomena which may be useful in fixing the time of death are first evaluated. Temperature of the body is taken rectally or by inserting a thermometer through a small abdominal incision deep into the liver. A long chemical thermometer or a metal dial type thermometer is satisfactory, but a clinical thermometer is not suitable. The degree of development of rigor mortis is determined by judging the stiffening of the muscle groups from the jaw downward to the feet. Rigor is readily lost in the neck muscles if the body is moved, and this may explain the apparent anomaly of stiffening of the muscles of the jaw and upper extremities with a limp neck. Post-mortem lividity should be observed for extent, location, and unusual color, such as the bright cherry-red color seen in carbon monoxide poisoning or the brownish color associated with methemoglobinemia due to various causes. Post-mortem discolorations on both the anterior and posterior surfaces of the body suggest that the body was moved before livor became fixed (six to twelve hours). Extent of putrefaction indicated by discoloration of the skin, "marbling" of the veins, blood formation, and slipping of the epidermis proceeding to advanced destruction of soft tissues should be recorded. Maggots, pupa cases, beetles, or other evidences of insect life should be preserved in glass vials for submission to the entomologist. Presence of lice and fleas and whether they are alive should be noted. "Goose flesh" or the sodden "washerwoman" shrunken skin may suggest submersion in water.

All surfaces of the body including the back and axillae must be examined. An assistant is essential to turn and hold the body for leisurely and methodical inspection by the pathologist. Failure to examine all surfaces of the body will sooner or later lead to embarrassment. We have seen a wound in the back made by a .22 caliber projectile pass unnoticed through superficial examinations by two physicians—it was finally discovered by an undertaker! Small wounds made by instruments such as hatpins or ice picks are particularly troublesome and more markedly so if they are concealed by thick or kinky hair (Fig. 3).

Every external evidence of injury, no matter how insignificant, must be measured and accurately located with regard to fixed anatomical landmarks. The nipple, for example, is not a fixed point but varies in exact location in different individuals; the heel or the top of the head are the most satisfactory points of reference. Charts of the body surface are very useful for the diagramming of wounds. The usually available charts, however, are inaccurate and do not satisfactorily depict all body surfaces. We have prepared our own series of charts which are free of unessential and confusing artistic embellishments but which are correctly proportioned and show the back, top, and front of the head, including the face and neck; the lateral head and neck; the anterior and posterior trunk; the lateral trunk including the axilla; the dorsal and ventral surfaces of the arms and hands; the legs from the anterior, lateral, and posterior aspects; and the plantar surface of the foot (Fig. 4). The charts are on standard 8½ by 11 inch sheets, which allows space to sketch wounds or other marks and to make notes along the borders. Charts should be prepared during the actual course of the examination, and when properly executed are sometimes more helpful than photographs in refreshing memory or as aids to court testimony.

To measure the distance of a wound from the desired fixed anatomical point, an instrument such as an anthropometer is very useful. This is essentially a double length meter and yardstick with one fixed and one sliding caliper point. Such a tool is easily made from materials at hand. In practice it is seldom possible to reduplicate exactly distances measured over the body contours with a flexible tape measure. It should be specified whether measurement is taken to the lower border, the midpoint, or the upper border of a particular wound. All measurements should be expressed in both English and metric figures since much explanation will be necessary to convey the significance of metric units to judge, jury, and lawyers. This is not necessary in expressing the weights of the viscera since these figures will require explanation in whatever system recorded.

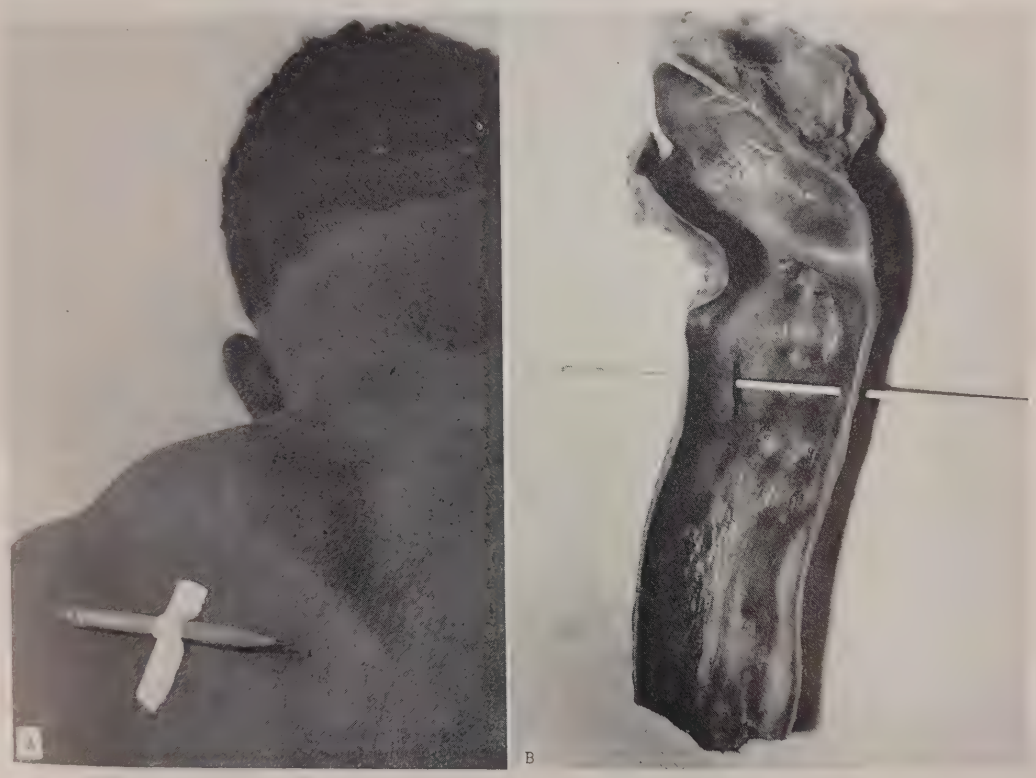

Fig. 3.—*A*, Ice-pick wound of back (at point of pencil). *B*, Penetrating wound of aorta which resulted in fatal hemorrhage.

All dimensions of a wound should be recorded, but depth is not determined until actual dissection begins. The borders of open wounds may be gently separated with retractors or small dissecting hooks as an aid to the determination of the exact size and shape, but it must be emphasized again that probing, enlarging, or otherwise permanently disturbing the wound is to be avoided at this point. A small opaque celluloid or plastic ruler of the type supplied in dissecting kits is very satisfactory and more easily handled than a tape measure or a large meter stick. Any peculiar or distinctive pattern of the injury is carefully noted for correlation with possible weapons (Figs. 5 and 6). If a weapon is presented by the police, do not attempt to fit a square axhead or a knife blade, for instance,

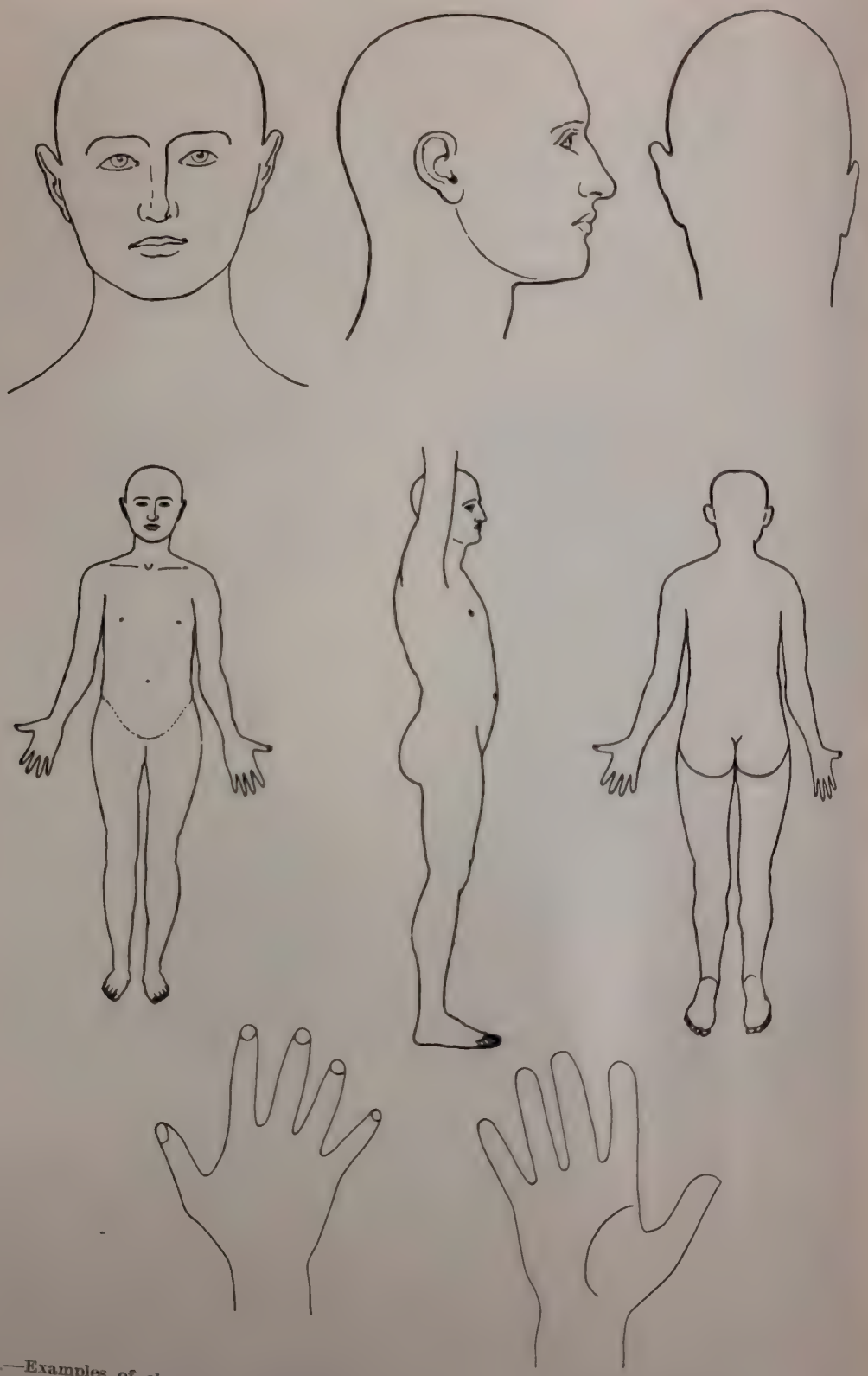

Fig. 4.—Examples of charts for diagramming external findings. Unnecessary lines and confusing details are not present.

into the wound; the wound may be distorted or the suspected instrument contaminated with blood. Multiple injuries are conveniently designated numerically, but it must be specified that the numbers are for descriptive purposes only or a false impression may be conveyed as to the order of infliction. Preservation of foreign materials lying in the wound or embedded in the bordering tissues has been mentioned.

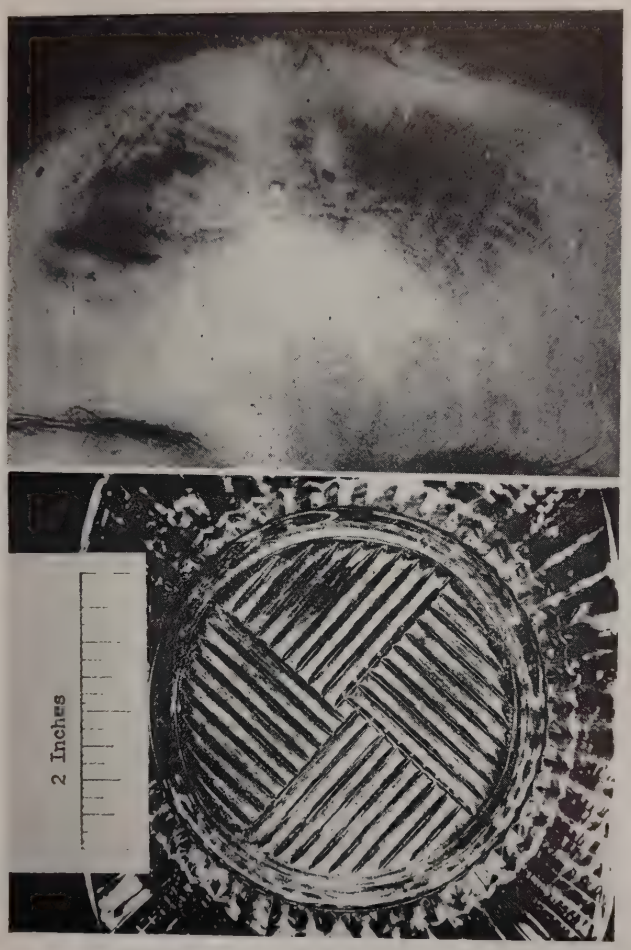


Fig. 5.—Pattern wound inflicted by the bottom of a glass ash tray.

Gross examination will usually supply a general idea of the age of the injury. Microscopic study will be necessary for more precise information. Moritz[30] and Russell[21] have summarized these complicated changes which must be interpreted by the expert. The principal points to observe with the naked eye are: evidences of hemorrhage into the wound and adjacent tissues, the presence of coagulated blood between the wound margins, retraction of the wound borders, beginning of the healing process, or signs of infection. Bear in mind that very extensive post-mortem injuries may be caused by predatory animals such as rats or, in the case of bodies in the water, by fish, sharp rocks, or passing ships (Fig. 7). Ants

may be responsible for distinctive post-mortem injuries, which are superficial dried parchmentlike defects in the skin showing irregular borders.

Abrasions are beveled at the beginning of the injury and show slight piling up of the skin with ragged serrated borders and small tags of skin at the terminal border. Consideration of these factors may establish the direction of the scraping force. Abrasions about the neck caused by fingernails are of importance in manual strangulation. Post-mortem abrasions are commonly inflicted when the body is handled and are characterized by pale-yellow dried-parchmentlike appearance without evidence of vascular response.

Fig. 6.—*A*, Wounds of distinctive pattern inflicted by a heavy expansion bit designed for use in an electric drill (from Ann. West. Med. & Surg. 4:486, 1950). Details of the weapon are seen in *B* and *C*.

Bruises pass through a series of color changes in the living body, and the presence of these color alterations is significant evidence of ante-mortem origin. These changes may be described as: reddish purple, bluish purple, blue, brown, yellow, and finally yellowish green. Description is somewhat subjective, and the examiner should formulate his own standardized terms. These color changes are not reliable in fixing the age of the contusion except within very broad limits. Again sections should be retained for possible microscopic study. Post-mortem lividity may be misinterpreted as bruising, but incision into the suspected area is helpful, since post-mortem discolorations are in the early stages due to blood

within the vessels which readily washes away from the cut surface. If decomposition has begun, the tissues may be stained and the discoloration fixed so that microscopic examination is essential for differentiation. Kerr[32] has summarized the differences between post-mortem discolorations and ante-mortem contusions:

| *Bruise* | *Lividity* |
|---|---|
| Swelling (possibly) | No swelling |
| Abrasion | No abrasion |
| Color changes | Color uniform |
| Situated anywhere | On dependent parts |
| Incision shows extravasated blood | Incision, blood in the vessels |

Fig. 7.—Post-mortem damage done by sharks to a floating body.

Contusions may show distinctive patterns which should not be overlooked, although they will not be as clear-cut as patterns seen in wounds with actual disruption of the skin surface. In all violent deaths the soft tissues of the back should be incised down the midline and reflected laterally to expose deep bruising

of the back, buttocks, or over the scapulae. Very extensive external bruising may not necessarily be associated with significant injuries when examination is carried further. This is particularly true in chronic alcoholics who fall and stumble frequently and who are often likely to bleed easily due to liver damage or to vitamin deficiencies. Conversely, very extensive internal injuries may not be associated with visible external signs.[33] An individual may fall from a considerable height and show no external injuries although the internal injuries are severe and necessarily fatal. Extensive injuries to the abdominal viscera are not infrequently present without discoloration of the abdominal wall. Head injuries of great severity frequently show no external evidences of injury. When the scalp is reflected, there will usually be hemorrhagic discolorations of the undersurface in these cases, unless death has occurred after a considerable interval associated with some condition such as chronic subdural hematoma.

No class of wounds leads to so much difficulty as those caused by firearms.[30b,34] The old rule that the wound of exit is larger than the wound of entrance leads not infrequently to misinterpretation of contact or near contact wounds when the opposite is true. The "contact ring," resulting from the elasticity of the skin with indentation before penetration by the projectile, may be measured under the mistaken impression that it represents the true size of the entrance wound. The defect in the skin is usually smaller than the bullet responsible and should be measured first; then the ring of abrasion and discoloration immediately surrounding the wound borders is measured. Differences in the width of this ring at different points should be recorded, because this information may give some idea of the angle at which the projectile struck the skin.

Distribution and extent of powder-fleck tattooing may give indications of the direction and range of fire. If this information is desired, do not cut out an irregular piece of skin about the wound for submission to the expert. A scaled photograph truly depicting the situation will be more useful.[17b] The skin will not show these traces if the bullet was fired through clothing, and it becomes particularly important to preserve the garments in such a state that special techniques can be applied in the laboratory. Preservation of unburned powder particles lying in the skin or adherent to the clothing has already been discussed. After the wound has been studied and recorded, it may be desirable to excise it to facilitate spectrochemical studies of the borders. Both entrance and exit wounds are required and the specimen should include about ¼ inch of tissue around and beneath the wound. It is preferable to submit the adjacent skin to the expert for removal of partially burned powder particles embedded beneath the skin surface. Carefully note smudging, tattooing, or other unusual features of the hands. Do not wash the hands, since chemical studies of powder residue may become important.

It is misleading and may do irreparable damage to stick a probe or some object such as a straightened coat hanger through the alleged tract from entrance to exit and conclude that this represents the true course of the bullet. Rather the course of the bullet must be determined by painstaking dissection under direct vision in logical sequence through the tissues penetrated. Rib borders or

the borders of other bones must be examined very carefully for roughening or other damage which may explain the deflection of the bullet.

If there are multiple tracts, each should be followed from point of entrance to termination without unnecessary disruption of relationships. A fluoroscope will save a great deal of time in locating bullets which are not readily found by dissection. A pitcher or similar basin placed under a faucet-type pump before blood is aspirated from the body cavities will prevent loss of loose bullets down the drain. All bullets present must be recovered and preserved with a clear notation as to the correct relationship of the particular bullet to the corresponding wound. It may become important after a shooting melee to know which of several weapons may have fired the fatal shot. Care must be taken to avoid defacing the bullet with a chisel or hemostat during removal. Fingers or forceps protected with rubber tubing are recommended for any necessary handling. The recovered bullet is wiped dry, but is not washed since washing may dissolve powder residue still adherent to the base. It is also advantageous to lay the bullet on the chart and to trace the general outlines. The autopsy surgeon marks the bullet on the base for later identification in court (Fig. 8). The mark

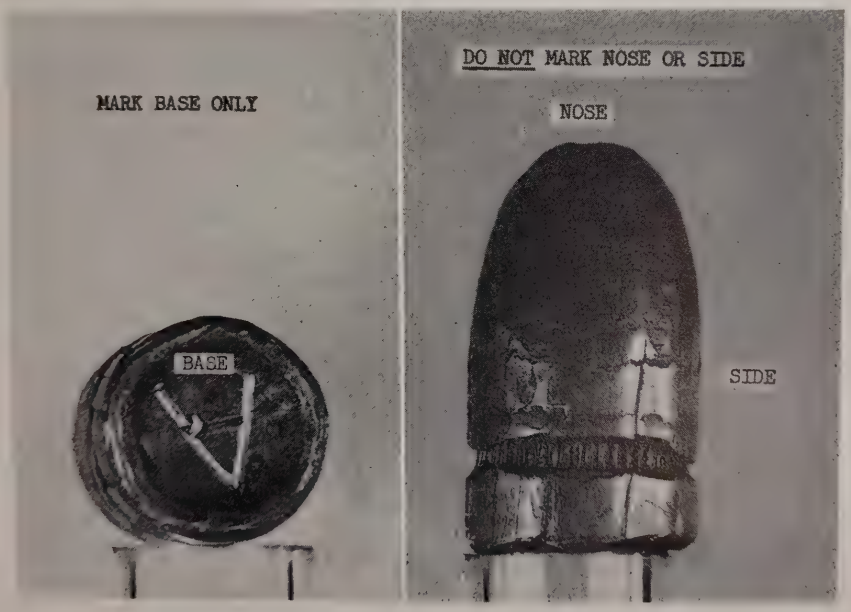


Fig. 8.—Proper way to mark a bullet for later identification.

is made with any convenient sharp-pointed instrument but should be as small as possible and should be something more distinctive than an "X." The nose of the bullet may show textile or other patterns and should not be marked. *Never is a mark to be made on the side of the bullet.* The recovered bullets are wrapped in cotton and placed in pillboxes or stored in paper envelopes, which are labeled by the autopsy surgeon in his own handwriting. Bullets are stored in a locked file until delivered to the ballistics expert, who gives a written receipt. Shotgun pellets also should be recovered but are not marked for identification. Any wadding present in a shotgun wound is carefully dried and preserved.

Entrance wounds in the mouth or throat may be overlooked. Helpern[11] reports entrance wounds through the orbit which were concealed by the closed eyelids. Examination of the eyeglasses in one of these homicides showed perforation of the lens, which was the first indication of the true cause of death. Other freakish gunshot wounds are occasionally observed. Rarely two bullets may enter through the same opening, or deteriorated ammunition may cause stoppage in the barrel of the first bullet, which is then propelled forward and into the body along with the second bullet when the weapon is fired again. A bullet which enters the neck may drop into the trachea and lodge in the bronchus. A bullet entering the mouth may be swallowed; a bullet penetrating the intestine may be carried away by peristalsis. If the projectile penetrates the aorta, it may be carried downward into the external iliac or femoral artery. Straus[35] reports a case of pulmonary embolism due to a .32 caliber bullet following a gunshot wound of the abdomen. A projectile may be deflected by a rib or by the skull and may travel subcutaneously around the periphery of the skull or thorax without penetration of the cavity. The wound of exit is puzzling until the relation to the entrance wound is properly established, or the spent bullet may be recovered just beneath the skin at a point some distance removed from the point of entrance.

Penetrating wounds, which are typified by stab wounds, should be followed under direct vision in proper order through the structures penetrated. The length of the wound tract from the skin surface to the termination is important in eliminating or implicating suspected instruments produced in the course of investigation. The nature of the structures penetrated such as rigid skull, semirigid thoracic wall, or yielding abdominal wall may influence opinions of this type. Information regarding the direction of tract upward or downward or from right to left is also important in reconstructing the crime. Fragments of knife blade, scissors, or other instrument are gently wiped, air dried, and preserved as indicated previously, if they are present in the depth of the tract.

All of these remarks concerning the meticulous enumeration and description of wounds apply also to clinical practice. Not infrequently the victims of criminal attack live for a variable time, and at autopsy wounds are either sutured, practically healed, or have disappeared. The surgeon's record then becomes a chief source of information to reconstruct the crime.

The purpose of the medicolegal autopsy is sometimes oversimplified to involve only the determination of the cause of death. Actually other possible causes of death must be ruled out, and all abnormalities present must be given proper weight in relation to the fatal outcome. Then, too, evidence vital to the prosecution of crime must be collected. With these broad objectives in view it is difficult to see that the medicolegal autopsy should be other than complete and painstaking in its performance. Yet in many jurisdictions it is not considered necessary, or it may even be counter to the existing laws, to proceed further than necessary to establish a reasonable cause of death. With this in mind, some compromise may have to be made with the ideal, and yet it is strongly recommended that at least the cranial, thoracic, and abdominal cavities should be thoroughly explored in any but the most routine and clear-cut cases. Individuals with severe coronary atherosclerosis may die from unsuspected head injuries,

polycystic kidneys may lead to hypertension and fatal intracerebral hemorrhage. Alcoholics with fatty metamorphosis of the liver may suffer unsuspected trauma to the head and die of subdural hemorrhage. A person dead of carbon monixide poisoning may have been struck on the head and rendered insensible before being placed in the gas-filled room. The improvement of this situation must depend upon a persistent educational campaign, publicizing of errors and miscarriages of justice predicated upon inaccurate medical evidence, and constant pressure for the improvement of legislative provisions. Many medicolegal autopsies are completed without microscopic study, but very minimum standards require that blocks of tissue at least be held for microscopic study in the event supplemental information is needed. It is not expensive and does not require a great deal of space to store small blocks of tissue in proper preservative for an adequate period after the gross autopsy.

From this point it is desirable to discuss certain practical aspects of the medicolegal autopsy as related to the major body regions and as related to the major classes of cases encountered in the daily practice of forensic medicine. Step-by-step technique will not be given since we have already stated our position that this work should not be undertaken by those unfamiliar with the fundamentals of pathology. The practical manuals of Farber,[7b] Saphir,[26b] and Shennan[36] supply adequate details as to standard autopsy practice.

## AIR EMBOLISM AND FAT EMBOLISM

Air may enter the circulatory system either by way of the peripheral veins or by way of the pulmonary veins. The first event leads to the presence of noncompressible frothy fluid in the right side of the heart and to obstruction of the pulmonary blood flow by this air trap. This is called "pulmonary" or "venous" air embolism and has been reported following many diagnostic and therapeutic procedures including irrigation of the maxillary sinus, vaginal insufflation, tubal patency tests, pneumoperitoneum, perirenal air injection, operations opening veins of the head and neck, and intravenous injections. In legal medicine, criminal abortion is the most common cause, but wounds which open large gaping veins about the head or neck are also important.[30b,37,38]

The second type of air embolism is called "arterial" and implies the presence of air in the left side of the heart and in the systemic circulation. Death is due to the obstruction of blood flow through the coronary or cerebral arteries by these air bubbles. This accident results when pulmonary parenchyma, air passages, or pulmonary veins are penetrated and in legal medicine is usually associated with penetrating wounds of the chest. Thoracocentesis and the induction of pneumothorax are the dangerous therapeutic procedures in this regard. Air may pass from the right to the left heart through a patent foramen ovale, or some air may pass through the pulmonary circulation and appear ultimately in the arteries.[30b,37,38]

Examination for the presence of air embolism must be made at the outset of the internal examination. Care is taken not to open large blood vessels and the sternum is reflected upward without dividing the first and second costal cartilages. Pericardium is opened and held by hemostats to form a bowl-like receptacle

which is filled with water. The right heart chambers and pulmonary arteries are then punctured under water to show the presence of air bubbles. Generally a considerable amount of air will be present in positive cases. Also the vena cava may be opened under water by flooding the abdominal cavity. Kulka[39] has suggested a refinement of technique employing an apparatus which allows preservation of aspirated gas samples for analysis. A nonleaking 50 c.c. syringe partially filled with water also may be used.

Arterial air embolism is diagnosed by the presence of air bubbles in the coronary and cerebral arteries. Moritz[30b] cautions that the bubbles must be intra-arterial since air may be aspirated into the cerebral veins when the skull cap is removed. Gas bubbles in the blood vessels may be due to very early putrefaction and must not be interpreted as air embolism.

Injuries which fracture long bones or extensively damage adipose tissue may cause the entrance of liquid fat droplets into the circulatory system. Extensive burns are also reported to cause fat embolism in a high percentage of cases,[40] and fat embolism may result when fatty materials are injected into the body cavities for diagnostic purposes, or into the cavum of the uterus to induce abortion.[41] If a large amount of fat is thus forced into the blood stream, interference with the blood supply of vital organs may result. No organ is spared, but the brain and lungs are the most important. Respiratory difficulties associated with fat in the pulmonary vessels generally occur within hours after the injury, while the effects of systemic fat embolism will be manifest at a later period after the fat globules have passed the pulmonary barrier to enter the arterial circulation. Fat, of course, may enter the circulation at different intervals incident to manipulation of the injured part, and a patent foramen ovale may allow passage from the right to the left heart without passage through the lungs.

Robb-Smith[42] describes the gross appearance of the lungs in fat embolism as follows:

> "They are heavy and voluminous and feel firm but not solid and there is no difference in consistency between apices and bases; there is no pleural effusion and the visceral pleural surface has a marbled appearance, zones of dark hemorrhage alternating with areas of emphysema. The lungs cut with some resistance and discharge a forthy, blood-stained fluid; globules of fat can often be seen on the surface; when squeezing, similar fluid exudes but it does not flow so readily as in cases of acute pulmonary edema. The cut surface shows the same mottled appearance of emphysema, edema and hemorrhage as that seen on the external surface. The hemorrhages are limited by the pulmonary septa and are not wedge shaped, nor is the congestion so extreme or the outline so precise as in cases of infarction. The bronchi contain frothy pink sputum and the branches of the pulmonary artery are dilated, containing liquid blood. The visceral pleura and pericardium may show scattered hemorhagic areas 3 to 5 mm. in diameter—the asphyxial hemorrhages of Tardieu."

Petechial hemorrhages over the skin of the shoulders and chest, in the conjunctivae, in the white matter of the brain, and perhaps in other viscera are suggestive of systemic fat embolism.[43]

Fat embolism must be searched for as a possible cause of death in individuals, the victims of beatings, who show extensive soft tissue damage without injuries sufficient to account for death.[8,b,c] If the possibility of fat embolism is remembered, tissues will be saved for special fat stains. Fat stains are done on frozen sections, and all the histological material must not be processed through paraffin before fat embolism and fat stains are considered.

Bone marrow fragments also may be forced into the circulation as the result of fractures involving bones containing red marrow. Convulsions resulting in damage to the vertebral bodies are to be thought of in this connection particularly. The significance of this type of embolism is not yet clarified, but certainly embolization may be so extensive as to impair the pulmonary circulation. Microscopically bone marrow fragments will be seen in the interalveolar capillaries, usually near the pleural surface.[44]

## CRANIUM AND CONTENTS

Note the distribution and character of all hemorrhagic discolorations visible on the undersurface of the scalp or beneath the galea. The dura must be stripped from the base and vault of the skull to study fracture lines. Observe unusual thinness or thickness of the skull. Measure and chart all fractures and look for separation of fragments and blood between the fragments. Do not confuse suture lines with fractures—"springing" the fragments is useful in this connection. Note volume, distribution, and maximum thickness of extradural and subdural hematomas. Sections should be retained to estimate the age of these hemorrhages. Note distribution and thickness of subarachnoid hemorrhages. Aneurysms of the circle of Willis are sometimes difficult to demonstrate, but injection of water with a syringe into the basilar or internal carotid arteries may show the site of rupture with disruption of the vessel. Chart all contusions on the surface of the brain. These, together with discolorations of the scalp and configuration of skull fractures, are helpful in reconstructing events preceding death. Open the dural sinuses and examine for evidence of thrombosis.

Increased fluid in the subarachnoid space, flattening and bulging of the brain, consistency of the brain substance, grooving of the uncus, and prominence of the cerebellar tonsils should be noted. Areas of brain showing petechial hemorrhages are retained for possible fat stains. Sections at the borders of intracerebral hemorrhages may show brain tumor to be the underlying condition. Observe the basal ganglia, particularly the globi pallidi, for evidences of softening associated with prolonged anoxia. Marked cerebral atrophy, with or without evidences of extensive healed cerebral trauma, may be associated with sudden death. This is purely an empirical observation and requires further elucidation. A series of frontal sections after removal of the brain stem will satisfactorily expose pathological changes in the cerebral hemispheres. Fixation facilitates this type of dissection.

## NASAL SINUSES, ORBIT, INTERNAL EAR, AND NASOPHARYNX

Ethmoidal, sphenoidal, and frontal sinuses are inspected by chiseling away the overlying base of the skull after removal of the brain. Inspection of the maxillary sinus involves careful dissecting away of the overlying facial tissues by prolonging downward the anterior scalp flap followed by chiseling away of the anterior bony wall, but in practice it is not often necessary to examine the maxillary sinus. The orbit and its contents are examined by chiseling away the orbital plate from above. Internal ear is examined by carefully chiseling away the superficial central portion of the petrous bone after removal of the brain. Infection in the sinuses or inner ear may explain meningitis, brain abscess, or extradural abscess. The nasopharynx should be examined when there is discovered aspirated blood from an unknown source. In one of our cases asphyxia resulted from aspiration of blood following superficial laceration of the posterior pharyngeal wall incident to insertion of an airway. Without thorough investigation this case probably would have been classified as an anesthetic death. Chiseling away the base of the skull overlying the nasopharynx has given satisfactory exposure in our experience. Harke's method involves splitting the base of the skull into two sections which are then widely separated to expose the structures of the nasopharynx.[45a] Polson[45] has recently reported a reasonably simple method for removing the nasal structures.

## SPINAL CORD AND VERTEBRAL COLUMN

The spinal cord is removed either posteriorly by cutting through the laminae or anteriorly following the procedure recommended by Kernohan.[47] A vibrating electrical saw of the Stryker* type is a great timesaver and is safe for these procedures. The cord also may be removed without disturbing the vertebrae, employing a V-shaped cutting tool on a long handle which is inserted through the foramen magnum from above.[48] Fracture of the cervical vertebrae or of the odontoid process should not be overlooked in sudden deaths without apparent anatomical changes. Blood welling up through the foramen magnum when the brain is removed is suspicious. Anterior portions of the vertebral bodies are sawed or chiseled away to inspect the vertebral bodies and intervertebral discs for dislocations and fractures.

## NECK ORGANS

A very essential part of the medicolegal autopsy is the examination of the neck structures, and the operator should be sufficiently proficient to remove these structures as a unit without distortion or damage. Szanto[49] has summarized the many techniques available, but in practice we have found that the following fairly simple, generally practiced method is satisfactory:

The shoulders are elevated on a block, allowing the head to drop backward. The V-shaped skin flap, resulting when the main autopsy incision was made, is dissected away from the underlying neck structures anteriorly and is reflected

*Manufactured by the Orthopedic Frame Company, Kalamazoo, Michigan.

upward. Inner ends of the clavicles are removed to give wide exposure. Lateral attachments of the esophagus, trachea, and muscles are then divided. The head should be dropped as far backward as possible and a long slender knife is inserted through the floor of the mouth near the symphysis of the mandible, and the tissues are divided along the rami of the mandible on each side to the posterior pharynx. The knife is then inserted behind the esophagus, and the posterior pharyngeal wall is divided. The tongue is drawn downward with the hand and the soft palate is cut. Traction is applied and any remaining tissue attachments are severed. The entire tongue should come away with the specimen. In unembalmed cases the carotid arteries must be preserved and branches which are cut are to be tied.[45 b]

The larynx is examined for evidences of edema and inflammation. Any membrane present in the larynx or trachea is noted and smears and cultures are taken. Particular note should be made of the presence of foreign bodies. Sudden deaths in children are not infrequently due to the aspiration of beans, pebbles, or parts of toys into the larynx, and the cause of death may be a problem unless the neck organs are examined. Alcoholics particularly may aspirate large masses of food into the larynx. The food bolus is often so tightly impacted that considerable force is necessary to remove it. Many of these individuals die very suddenly, and death may be considered to be due to heart disease or other natural causes if the foreign body in the air passages is overlooked.

Hemorrhages or evidences of injury to the muscles or soft tissues are carefully noted. Fractures of the laryngeal cartilages, tracheal rings, and hyoid bone are searched for. If the hyoid bone is fractured, incision should be made and the presence of blood between the fracture fragments demonstrated. Mucosal hemorrhages within the larynx may be found in cases of manual strangulation. Transverse tears in the carotid intima are described in hanging. Note has been taken of the importance of superficial scratches or bruises on the external surface of the neck in cases of manual strangulation. The thyroid and parathyroid glands should be examined. The oropharynx should be examined from above, as indicated previously, or can be examined from below with the aid of a flashlight after removal of the neck structures.

## THORAX

Soft tissues are examined for evidences of injury. Rib fractures are demonstrated by dividing the soft tissues on either side of the suspected fracture site and moving the fragments. Look for pleural perforations. Character and amount of transudate, exudate, or hemorrhage present are noted. Pleural surfaces are examined for petechial hemorrhages. Lungs are examined for presence of consolidation, cavitation, emphysema, and tumor. The tracheobronchial tree should be opened with scissors and the character of the contents noted. Look particularly for foreign material such as silt or grass in suspected drowning. Aspiration of blood may account for death in a person unconscious after injuries. Aspirated vomitus is looked for; it may be helpful to test the reaction of the material in the lumen of the tracheobronchial tree with litmus paper. Pneumothorax will be indicated by a collapsed lung but may be tested for at the begin-

ning of autopsy by pouring water into the pocket formed between the skin flap and the chest wall and puncturing the chest cavity while watching for air bubbles through the water.[30d] The right auricle, right ventricle, inferior vena cava, and pulmonary artery may be opened in situ to demonstrate emboli. Pulmonary arterial system is opened completely after removal of the lungs. Detached thrombi which enter the venous circulation and come to lie in the pulmonary arteries usually originate in the deep veins of the lower extremity but may also originate in the pelvic veins. If it is not feasible to dissect out the veins of the lower extremity in cases of pulmonary embolism, the extremity may be "milked" upward by steady pressure to force bland thrombus out of the divided iliac veins. The character of the blood which flows into the chest when the thoracic viscera are removed should be noted as to color, consistency, and the presence or absence of clotting.*

Pericardial surfaces are described and are observed for petechial hemorrhages which are common in asphyxial deaths. The weight of the heart, circumferences of the valve orifices, valvular abnormalities, and the thickness of the ventricular walls are recorded. Coronary arteries should be examined by means of transverse sections about 4 mm. apart. Opening the arteries longitudinally may dislodge thrombi and makes it difficult to judge the degree of reduction in the size of the lumen. The degree of reduction in the size of the lumen should be recorded in exact figures, either in percentages or in millimeters. Old thrombi or severe atherosclerosis are more frequently seen than is a fresh thrombus occluding a coronary artery. Embolus, rupture of a grumous atherosclerotic plaque, and hemorrhage into an atherosclerotic plaque must also be considered as causes of sudden obstruction. Microscopic study is frequently essential for accurate

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*An improved technique for demonstrations of lesions of the coronary arteries was presented by S. H. Durlacher at the meeting of the American Academy of Forensic Sciences, Feb. 26 to 28, 1953. (See Proceedings of this Academy, not yet published.) The technique is a method of perfusion, fixation, decalcification, and clearing of the vessels, and gives the examiner an opportunity to visualize the entire vessel wall and its contents prior to sectioning and embedding without introduction of artefact.

With the heart in situ, make an incision of the pulmonary artery and examine its contents. Excise the heart by severing the great vessels at their pericardial reflection; drain the content of fluid and clotted blood before weighing. The cardiac and ascending aorta are tied around a large cannula, and normal saline is perfused under 100 mm. of mercury pressure. With the fluid escaping from the coronary sinus becoming clear, 10 per cent formalin is perfused under similar pressure for 10 minutes. Remove the heart from the perfusion apparatus and suspend in 10 per cent formalin. After several hours the coronary vessels with an abundant layer of subepicardial tissue are dissected from the heart, commencing the dissection at the mouth of the arteries, and the major arborizations are preserved intact.

After removal of these vessels the heart may be examined in the usual manner. Decalcify the arteries in a 5 per cent nitric acid, and neutralize with a weak solution of lithium carbonate. Dehydrate by successive changes of 70, 80, and 95 per cent alcohol for a period of 8 hours each. Immerse the vessels in the clearing agent consisting of a 1:1 mixture of methyl salicylate and methyl benzoate until transparent. Now the tissues surrounding the vessels can be removed with ease. Gross examinations of the vessels are made at this stage by transmitted light, and changes in the wall or obstructions in the lumen are readily apparent. Introduce air into the mouth of the vessels to delineate the lumina. Section the vessels transversely and examine blocks from the cut surfaces. Appropriate segments can be selected for embedding and sectioning. Paraffin blocks may be prepared by putting the cleared segments first into benzene and then into paraffin; or the tissues may be dehydrated and embedded using any of the standard dehydration techniques.

This method has the advantage of removing any unclotted blood from the lumen. The pressures used for perfusion are within the physiologic range and will not disturb delicate thrombi.

Fixation of the vessels and their contents prior to the sectioning hardens the tissues and prevents loss of the thrombi from the lumen and loss of the softened atheromatous material from the walls. Note also that decalcification of the vessels prior to sectioning facilitates cutting and prevents the formation of artefacts due to the application of pressure to the hard, fragile tissues. (Ed. note.)

classification. The myocardium is examined by making thin parallel sections in the long axis of the ventricular walls and septum. Sections of infarcted areas must be saved since it frequently becomes important to estimate the age of a myocardial infarct.[50] Endocardial surface is examined for hemorrhagic areas.

The general condition of the aorta is noted with particular reference to narrowing of the coronary ostia by syphilitic aortitis or atherosclerosis. Syphilitic, dissecting, or arteriosclerotic aneurysms are frequently a cause of death. Aneurysms may rupture into the pericardial sac, into the chest cavities, into the air passages, into the gastrointestinal tract, or retroperitoneally into the soft tissues and must be ruled out as causes of hemorrhage in these areas. It is unwise to classify an aortic lesion as syphilitic without microscopic confirmation.

## ABDOMEN

Amount and character of any fluid or blood present are reported. Gastric contents may be present in the abdominal cavity due to gelatinous softening of the gastric wall and subsequent perforation. Such softening and perforation may also involve the lower end of the esophagus with gastric contents spilled into the left chest cavity. Rokitansky[51] realized that such softening was frequently associated with brain damage due to various causes, and modern thought is in accord with this view. Head injury is the most frequent antecedent condition.[52,53] At any rate such changes represent more than agonal or post-mortem digestion and, when observed, suggest that examination of the brain is in order. This appearance is not an indication of poisoning as is sometimes erroneously supposed.

The contents of the stomach merits careful observation. The amount, odor, color, stage of digestion, and recognizable food residues are the important points. This information may be useful in fixing the time between the last meal and death or in establishing identity.

Missing organs for purposes of record should be correlated with abdominal surgical scars.

The examination of the gastrointestinal tract in cases of suspected poisoning will be discussed subsequently.

Kidneys and ureters may be examined and then detached from the bladder unless some specific indication exists for the removal of the genitourinary organs as a unit. Testes are pushed into the abdominal cavity after enlarging the inguinal ring and are sectioned in the long axis. Examination of the female genitals is considered in connection with abortion.

## SUSPECTED CRIMINAL ABORTION

It is well in medicolegal work to adopt the cynical attitude that any sudden unexplained death of a woman of childbearing age may be related to an attempt to terminate an unwanted pregnancy. The importance of testing for air embolism at the beginning of the autopsy has been emphasized.

The pelvic organs are removed as a unit by dividing the fascial planes of the pelvis and cutting through the bladder neck, vagina, and rectum. The cut should

be decisive and clean to avoid confusing secondary injuries. The rectum is examined for possible perforations and then is dissected away. The vagina and uterus are then opened posteriorly. A basin should be at hand to catch any fluid which may be present in the uterine cavity. The uterus is measured in its greatest dimensions of length, width, and thickness. Careful examination is made for perforations which may be due to instruments. The endometrium is examined for evidences of roughening indicating curettement or areas suggestive of recent placental attachment. Adequate sections are taken for microscopic study since it may be important to prove the presence of chorionic villi. A fetus if present is, of course, carefully measured and weighed, and all fetal parts are carefully preserved. Painstaking examination of the cervix is particularly important. The diameter or circumference of the endocervical canal and of the external os is noted and marks from instruments such as a tenaculum are measured, diagrammed, and photographed (Fig. 9). The mucosa of the vaginal canal is examined for abrasions, lacerations, or ecchymoses suggesting instrumental interference. Ovaries are examined for the presence of a corpus luteum which, if present, is measured and retained for microscopic study. Any suspected areas of abrasion or discoloration of the genital tract should be retained for microscopic study since it may become important to show evidences of vital reaction.

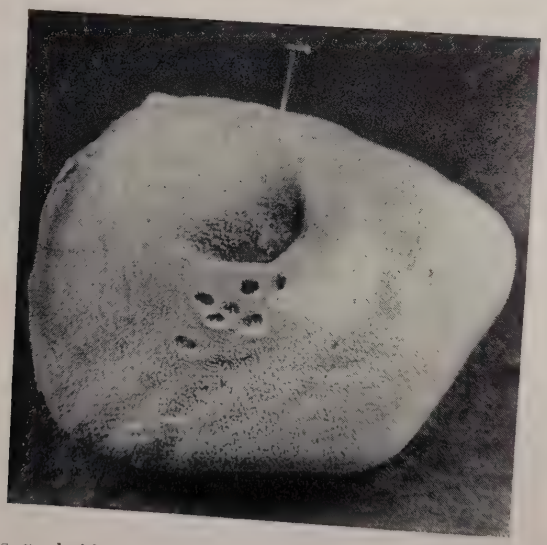

Fig. 9.—Instrument marks, probably due to tenaculum, on cervix in case of criminal abortion. These marks are unusually prominent.

Some authorities remove a segment of the symphysis pubis and remove the external genitals as well as the internal organs. In our experience this is not necessary if division of the vagina is cleanly performed and if the legs are spread widely apart and careful examination with adequate illumination is made of the external genitals and lower vaginal canal.

Early deaths incident to abortion are usually due to reflex shock, air embolism, hemorrhages, fat embolism when fatty agents are employed, or systemic poisoning from poisonous abortifacient agents injected into the uterus. Delayed

deaths are generally due to infection, sometimes with peritonitis. Infection with anaerobic organisms is not uncommon, and in some of these unfortunate cases gas will be formed in the tissues adjacent to the uterus and even in the abdominal wall which is crepitant when palpated. Lower nephron nephrosis is not infrequently a complication of induced abortion. It may be due either to anaerobic infection or is thought by some to be due to toxic tissue breakdown products produced at the site of uterine injury.[54-57] Microscopic sections of kidney will be necessary to diagnose this condition.[58]

Very severe injuries may be inflicted in the course of self-induced abortion employing sharp-pointed instruments and are not necessarily an indication of interference by a second person.

## DEATHS DUE TO POISONING

Final diagnosis in most deaths due to poisoning will be made by the toxicologist. However, complete post-mortem examination is necessary to rule out natural causes of death or to assess the relative importance of disease processes discovered.[59] If a poisoning agent is responsible for death, certain gross and microscopic changes may give indications as to the further course of laboratory investigations. Many instances of sudden or unexpected deaths will be attributed by laymen to poisoning, and a definite opinion and firm stand in the initial stage of the case will stop rumors and prevent unnecessary toxicologic studies. Thorough investigation of the circumstances and, particularly, a complete history of the final illness are very essential as guides to the investigation of poison deaths. This information, together with all chemicals and medicines on the premises, suspected utensils such as drinking glasses, articles soiled with vomitus, and suspected articles of food and drink, should be transmitted to the toxicologist. Irreplaceable material will be wasted and time and money expended in the processing of a "general unknown" without adequate preliminary investigation of the poisons reasonably to be considered. Clinicians should be taught to preserve gastric washings, vomitus, urine, and feces since many poisons are eliminated from the body before death and it is extremely difficult to establish the cause of death, at least for legal purposes, without chemical confirmation.

Post-mortem ecchymoses are observed for unusual color. Skin may exhibit exfoliative dermatitis, eczematoid eruptions, pigmentation, keratoses (especially palms and soles), purpuric spots, or jaundice. Gingivitis or discolorations at the gingival margins are significant. Mouth and lips are examined for burns due to corrosives which may also involve the corners of the mouth or even the anterior chest wall due to coursing of the corrosive agent downward over these areas. Marks indicating hypodermic injections are particularly significant; in case of doubt the area should be excised and examined microscopically. State of the pupils is checked; although, in our experience, dilatation or constriction are inconsistent and are unreliable as post-mortem indications of poisoning.

Odors are valuable signs but are best detected early in the examination before obscured by more powerful influences. Many odors are more perceptible when the cranium is opened and the brain is sectioned, or others may best be perceived when the thorax is opened.

Corrosives may penetrate the gastric wall and affect adjacent structures. Corrosive action is usually most apparent in the fundal area of the stomach where pooling occurs when the body lies on its back. Irritant materials also may be aspirated into the tracheobronchial tree and lungs. Gastric contents are observed for unusual odor or color. Unusual colors may be due to the poisoning agent proper or to some inert added coloring matter (methylene blue in mercuric chloride disinfectant tablets). Other colored substances result from chemical changes in the agent after ingestion; arsenious oxide may be changed to the yellow sulfide during the early stages of putrefaction. Undissolved tablets and capsules are frequently important clues. Sometimes a large mass of colored gelatin and partially dissolved powder is present in the stomach after ingestion of a large amount of barbiturate, and the color of the gelatinous mass may give some indication as to the particular preparation ingested. Do not be confused by the color which wine may import to the mucosa of the stomach and upper small bowel. The confusing color imparted by the dye in embalming fluids has already been mentioned. Dilated small bowel showing engorged capillaries and filled with watery fluid and mucus flecks suggests acute arsenic poisoning. Ulceration of the mucosa of the colon may be due to mercury excretion, and such ulcers may perforate, with peritonitis resulting.

Serosal and mucosal surfaces are inspected for the presence of ecchymoses or petechiae. Adventitial hemorrhages may be numerous over the surface of the aorta in some types of poisoning. Hemorrhages near the tips of the papillary muscles of the heart or subendocardially in the heart may be significant.

Fatty metamorphoses of the liver and other parenchymatous viscera are noted if present. Hepatic necrosis is associated with many common types of poisoning. Unusual odor and color of urine are sometimes significant.

Brain is examined for subarachnoid hemorrhages, petechial hemorrhages, and areas of softening. Softening of the globi pallidi is most often associated with delayed death from carbon monoxide poisoning but is seen after cerebral anoxia from other causes.[60]

Microscopic sections should be taken in all cases of suspected poisoning since many of the pathologic changes are of microscopic nature and are at best only slight.[61]

The appropriate sections of this book should be consulted concerning the specific materials best suited for quantitative determinations of poisons. However, certain general suggestions may be of value.

Generous portions of all parts of both lungs are required for classification of the pneumoconioses. We do not like to diagnose silicosis without tissue silica levels to augment history and gross and histologic findings. Liver may show the presence of carbon tetrachloride for as long as twenty-four days after the exposure, but we have obtained better results with body fat.[62] Hair, toenails, and bone may be desirable in chronic poisoning by heavy metals, especially arsenic. Striated muscle is sometimes required for analysis in cases of suspected opiate poisoning.

Stomach should be tied at the esophagus and pylorus before removal to avoid loss of contents. It is opened in a glass or enamelware basin but should not be allowed to stand for a prolonged period in the latter type of container. At least a three-foot segment of the upper part of the small bowel is also tied at both ends before removal and is opened in a basin. Do not attempt to open the hollow viscera over narrow-mouthed jars as valuable material will be spilled. All urine in the bladder should be withdrawn and saved before the bladder is completely opened. Wide-mouthed fruit jars of pint or quart size are satisfactory for the storage of toxicologic specimens. Of course they must be chemically clean. Glass tops are preferable and the older type of zinc top should never be used since small amounts of arsenic may be present as impurities in these lids. Properly labeled bottles are wrapped in paper, tied with twine, and the knot is sealed with sealing wax and some distinctive device. Generally it is most satisfactory for the autopsy surgeon to deliver these visceral specimens directly to the toxicologist in order to shorten the chain of possession. Specimens should be kept cool or refrigerated until delivered to the laboratory and preservatives are not to be used. In emergencies pure ethyl alcohol (not rubbing alcohol or denatured alcohol) is permissible, but a specimen of the same alcohol should be sent to the toxicologist along with the specimens.

*Sufficient material should be submitted*—at least a whole kidney, the greater part of the liver, a kilogram of brain, all of the urine, all of the stomach and contents—submission of a few grams of tissues is the most frequent error made by those unfamiliar with the difficulties and intricacies of toxicologic analysis. One must learn to think in terms of hundreds of grams or kilograms rather than a few grams. Accurately determined body weight and weights of the organs are particularly necessary to compute the total amount of poison present as well as the distribution in the individual organs. In exhumations it is well to retain a portion of the coffin lining and filler, the coffin wall, as well as a portion of the earth in which the body is buried in order to refute claims that the poisonous agent entered the tissues after interment.

Determination of the alcohol level in brain and blood is an essential part of the workup of all violent deaths, and alcohol may play a major role in many natural deaths.

## SUIDICAL DEATHS

The final classification of a death as suicidal must be made after consideration of several factors. The assessment of these cases should be accurate since suicide in our culture has a certain aura of disgrace, together with the fact that considerable sums of money in the form of life insurance may be involved. History will be valuable, particularly if there is a long story of maladjustment or of previous attempts; ill health, financial reverses, or other "trigger mechanisms" are usually put forth as the motive for the suicidal attempt, but this is oversimplification and careful inquiry will usually reveal a more complex story. The study of a note, if left, will be invaluable to the medical investigator. The position of the body; the environment—elaborate preparations or complicated apparatus, doors locked on the inside—argue against homicide; presence of the

weapon near the body; distribution of blood stains on the body and environmental objects are all factors to be considered. Sexual deviates may employ elaborate apparatuses to suspend themselves in order to obtain sexual stimulation, and not infrequently plans miscarry so that suspension is carried to an irreversible point. These deaths are not suicidal but are truly accidental. Remember that an assassin cannot make the dead hand of his victim tightly clasp a weapon.

Generally speaking, wounds should involve parts of the body accessible to the victim himself. Multiple wounds may mislead the novice into suspecting homicide, but in practice the unfortunate victim may try several methods before one is successful. In one of our cases an aged man took "ant syrup" and supposedly died of arsenic poisoning after several days in the hospital. At autopsy there were three icepick wounds of the chest with massive hemothorax, and there were also superficial lacerations on the volar aspects of both wrists. An example, probably apocryphal, is cited in medicolegal circles of a man who shot himself in the chest, slashed his wrists, and then hanged himself from a gas fixture. The gas fixture broke, and illuminating gas poisoning was the actual cause of death. There was also carbolic acid in the stomach!

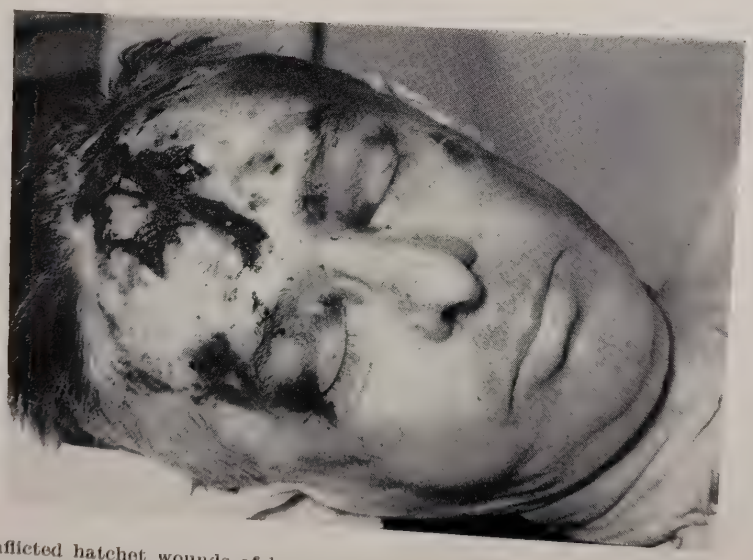

**Fig. 10.—Self-inflicted hatchet wounds of head. Death was actually due to nicotine poisoning after ingestion of an insecticide.**

Generally, multiple severe wounds mean ferocious attack and suggest homicide, but do not be misled by the appalling damage which suicides may do to themselves. Suicidal cutthroat wounds may amount very nearly to decapitation. Individuals have been known to make human torches of themselves after saturating their clothes with gasoline. The majority of suicidal cutting wounds, however, will show evidence of tentative or preliminary attempts at one border—the so-called "hesitation marks." The presence of wounds about the hands suggest an attempt to ward off homicidal attack. The head is not usually considered the site of suicidal wounds, but this is not always true (Fig. 10). In our

experience it has been unusual for skull fracture to be observed associated with suicidal head wounds, and certainly the presence of more than one fracture suggests some outside agency. All of the factors discussed under gunshot wounds must be considered in deciding whether a gunshot wound is suicidal, homicidal, or accidental. Hunting accidents, particularly, lead to difficulties. They are usually in the first instance considered to be accidental, and exhumation and subsequent examination, often unsatisfactory, can be avoided by thorough examination in the initial stages. In connection with gunshot wounds it may be of value to have the length of the arm recorded if it is necessary to give an opinion as to whether the distance of the weapon from the body could be consistent with self-infliction.

## SUDDEN AND UNEXPECTED DEATHS DUE TO NATURAL CAUSES

A great part of medicolegal work will involve deaths of this type in individuals who are apparently well, who are ill but do not seek medical attention, who die suddenly at work, or who are under medical observation but cannot be satisfactorily diagnosed to enable the attending physician to certify the cause of death. Detailed consideration of the autopsy findings in this group would involve discussion of all the myriad lesions and combinations of pathologic changes encountered in systemic pathology. Many of these persons will be walking museums of pathology, and it is almost a question of how life was so long maintained. Others will show very slight changes, and it is in regard to this group that the young pathologist fresh from hospital experience must adjust his thinking and accept the fact that very little in the way of anatomic alteration sometimes suffices to kill. The methods available to us at present are not adequate to show all changes in the organs and tissues of those dying suddenly, particularly young and healthy individuals. Some of these deaths also will be due to functional disturbances which leave no anatomic indications. Moritz and Zamcheck[62] in their unique study of autopsies on one thousand young soldiers dying suddenly and unexpectedly during World War II found that slightly over 10 per cent revealed no demonstrable cause of death. Probably this figure should be slightly lower if examination is done by a limited number of individuals all of whom are familiar with the necessity of uniform complete investigation and post-mortem examination. Some of these obscure deaths may be due to vasomotor reflexes with sudden vasodilatation and fall in blood pressure or to vagal inhibitory reflexes with slowing or stopping of the heart ("primary shock," "syncope") after minor injuries or stimulation of certain areas in susceptible individuals. Acceptance of such mechanisms presupposes a *complete* gross, microscopic, and perhaps toxicologic examination. It is no admission of incompetence to record "cause of death undetermined" in the official documents—opinions and theories can be offered later.

Status thymicolymphaticus is not, in our opinion, a cause of death, but represents rather a pre-existing situation which predisposes to sudden death following otherwise trivial stimuli or trauma. Unfortunately in the past this diagnosis has been widely used as a shield for slovenly or incomplete examination in medicolegal work, and the mere attachment of a name has been substituted for

adequate study. The enlarged thymus is most probably merely a part of the whole state and is not in itself responsible for death by mechanical or other means. Ridge[64] has proposed the interesting theory that tonguelike processes of thymic tissue may extend behind the sternum into the base of the neck and there may exert mechanical pressure on the vagus nerves with possible sudden death. This observation merits further controlled investigation.

The following suggestions are offered as aids in the elucidation of obscure natural deaths[65]:

Autopsy must be complete. Do not forget to remove and examine the neck organs, including the thyroid. In one of our cases of sudden death in a 27-year-old male, there was a diffuse thyroid hyperplasia without typical previous clinical history. In another case a 9-year-old girl had received for some time thyroid extract as an aid to weight reduction. Examine all branches of the pulmonary artery, all branches of the coronary arteries, bone marrow, ureters, and bile ducts for calculi; do not omit the examination of the spinal cord. Think of cerebral concussion, and look for small areas of subarachnoid hemorrhage and discolorations on the undersurface of the scalp. The possibility of electrocution, anaphylactic shock, asthma, epilepsy, and delirium tremens must be remembered. Most of our fatal cases of delirum tremens have shown rather advanced fatty metamorphosis of the liver. Fulminating infections of various types may be responsible. It is important to take numerous sections of all organs and remember to hold some of the material for special stains such as fat or iron if indicated by subsequent developments. It will be quite apparent that some of the conditions mentioned will never be diagnosed unless time and trouble are taken to obtain a history from those associated with the deceased person in life.

Test the urine for sugar and acetone. Note abnormal color of the urine which may suggest porphyrinuria. Submit blood for alcohol, creatinine, and glucose determinations. Save adequate amounts of all organs for possible toxicologic analysis, but do not be hurried into unnecessary toxicologic work without adequate indications from the history and anatomic findings. Take cultures for bacteriologic workup. Save blood (unembalmed) for complement fixation and agglutination tests.

It is unfortunate that many infants found dead in the crib are reported to have smothered in the bed clothing.* Adequate examination of these babies will usually show evidences of fulminating infection due to various bacteria or to viruses. It is a real service to inform a distraught and guilt-ridden mother that no neglect on her part led to the smothering of the infant in its crib. Mechanical restraints or cords attaching toys to the crib are, of course, another matter and may be responsible for true mechanical strangulation. It has been adequately indicated that such cases should not summarily be dismissed as status thymicolymphaticus.

Even though the pathologic lesions responsible for death are quite apparent, it is essential to have a complete description of these changes since matters of compensation may depend upon the establishing of the age of the disease processes or upon the relative weight to be given these changes in the total aspect of the

*See Chapter 14 on septal pneumonia in infancy.

case. Evidences of severe heart disease or of a ruptured aneurysm of the circle of Willis may somewhat mitigate the degree of responsibility on the part of an opponent if an individual dies in the course of an altercation. Many persons who die suddenly literally drop dead and may inflict what at first appear to be rather severe injuries to the soft tissues of the face or scalp, and many of these cases come to the coroner or medical examiner as cases of suspected homicide. Every case must be given careful attention since it is impossible to predict which cases will subsequently become complicated. The driver of a vehicle may have suffered a fatal heart attack before the impact, and the demonstration of this fact will materially influence insurance settlements. Airplane pilots, bus drivers, or locomotive engineers may die from natural causes, and otherwise inexplicable accidents thus become clear-cut.

## FRAGMENTARY REMAINS, DECOMPOSED BODIES, BURNED BODIES

The examination of decomposed or burned bodies is one of the most unpleasant tasks in forensic medicine, and temptation is great to be superficial and hurried. *No corpse is so foul or so extensively charred that some pertinent information concerning the cause and manner of death cannot be obtained by painstaking study.* Murderers frequently attempt to hide their crime by irregular disposition of the whole or dismembered body or by attempted incineration of the victim. Cursory inspection of these revolting specimens will sooner or later result in failure to discover the evidence of crime—a major function of the medicolegal expert.

A number of questions can be answered with ascending degrees of completeness depending upon the type and condition of material presented.[66-68] Tabulation of the essential features will serve as a guide if tempered by judgment on the part of the autopsy surgeon.

1. Animal or human remains?[69, 70]
   a. Precipitin test if tissue is present and decomposition is not too far advanded.
   b. Gross anatomical characteristics.
   c. Microscopic characteristics—the histologic pattern differs in animal and human bone.
   d. Chemical analysis of bone—composition of animal and human bone ash varies.[71]
2. Age of deceased person?[72]
   a. State of epiphyses.
   b. State of teeth and lower jaw.
   c. Calcification of laryngeal and sternal cartilages and hyoid bone.
   d. Changes in the sacrum.
   e. Closure of the cranial sutures.
   f. Condition of the symphyseal surface of the pubic bone.
   g. Changes in the joints.
3. Sex?[72]
   a. Configuration of the pelvis (heaviness of construction, pubic arch, curve of the iliac crest, greater sciatic notch, preauricular sulcus, body of the pubis, obturator foramen, size of acetabulum).

b. Size and shape of sacrum.
c. Configuration of the skull.
d. Size and configuration of the long bones.
e. Gross and microscopic examination of internal genitals. Prostate and unimpregnated uterus resist putrefaction for a long period (Fig. 11).

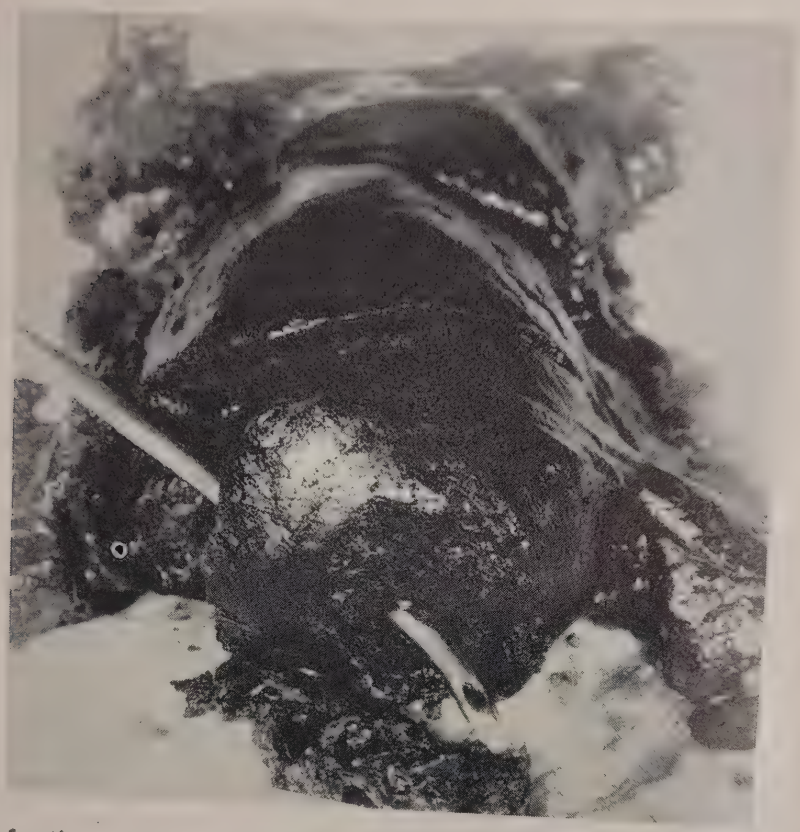

Fig. 11.—Perforation of uterus incident to criminal abortion, well illustrated in a body buried two and one-half years (probe inserted in perforation). It was possible to demonstrate polymorphonuclear infiltration in microscopic sections of this wound as well as in the borders of an associated perforation of the rectum.

4. Stature?[72]
   a. Measurement of trunk.
   b. Measurement of long bones and application of proper formulae.
5. Race?[72]
   a. Hair and skin if available.
   b. Bones, particularly the skull and pelvis, should be submitted to the expert anthropologist.
6. Identification?[72]
   a. *Fingerprints.* Shells of skin separated from underlying soft tissues may be placed over the gloved fingers of the operator in order to roll fairly satisfactory fingerprints, or the skin from the finger tips may be flattened between glass plates and photographed.
   b. *Dental Status.**
   c. Peculiar characteristics of bone or soft tissue (missing viscera, scars, tattoos, occupational stigmas, old fractures, chronic

*See Chapter 18 on dental identification.

disease of bone and soft tissue, congenital anomalies). Gallstones have aided materially in establishing identity.[73]

d. Roentgenograms of fractures may be kept on file and compared with x-rays taken of the same injury during the lifetime of the missing person.

e. Contents of the stomach may be correlated with the last meal eaten by a missing person.

f. Personal property or articles in close proximity to the body.

Fig. 12.—Diastatic fracture of both occipitomastoid sutures clearly visible in a skull buried four years. These are not of post-mortem origin.

g. Superimposition of photographs of the deceased person in life upon photographs of the skull. Accounts of the cases of Ruxton[68] and Dobkin[74] supply details. We found this procedure helpful in one instance, but we agree with the judge who summed up in the Dobkin case, "These photographs do not disagree, and if you take my advice you will not regard that as evidence more compelling than that."[74]

7. The cause of death?

a. Do as complete an autopsy as the condition of the body permits. Take blocks of tissue for microscopic study and retain tissues for possible toxicology even though post-mortem

changes are well advanced. Interpretation of the gross and microscopic autopsy findings, and the weight given these findings, of course, will be influenced by the particular state of the body.

b. Recover any bullets present (x-ray or fluoroscopic aid is very useful). Fragments of other weapons may be embedded in soft tissues or bone. Bullets should be placed in pillboxes, marked on top of box; no marks should be put on bullets so as not to interfere with a search for grooves and bands with the comparison microscope.

c. Note injuries to bony structures such as skull, hyoid bone, ribs (Fig. 12). Knife scratches on the cervical vertebral bodies and other bone or joint surfaces may be informative.

8. Special features

a. Purposeful mutilation (removal of identifying characteristics).

b. Indications that dismemberment was done by someone with or without anatomical training or some degree of skill and knowledge.

Unnecessary work may be avoided if fragmentary remains are tested for the presence of formaldehyde by any of several published methods employing chromotropic acid. The presence of formaldehyde in the tissues strongly suggests improper disposal of embalmed tissues or medical specimens (Fig. 13).

Fig. 13.—Decomposed arm discovered during excavation for sewer. Formaldehyde was still demonstrable in the tissues.

It is more satisfactory to transport the properly buried, exhumed body or the accidentally discovered remains of the victim of a crime to a suitable mortuary for adequate study. Improvised facilities in cemeteries or sheds only add to the difficulties. Of course, inspection at the time and site of exhumation or

discovery is highly desirable, but the actual post-mortem examination can be performed in more suitable surroundings. The examination should not be delayed, as decomposing remains when exposed to air deteriorate rapidly, and even an overnight stay in the refrigerator is undesirable.

Those charged with the removal of a number of dead bodies from the scene of a disaster should be instructed in the importance of order and system in gathering fragmentary remains and of keeping personal articles properly related to the body near which or on which they are found. This type of evidence is very often the least reliable in establishing identity, particularly if there is some conscious attempt by a criminal to mislead the authorities or if there has been a great deal of heat or disrupting force associated with the accident. The presence of a metallic identification tag embedded in the soft tissues of a burned body does not necessarily, without further examination, prove the body is that of the soldier named on the tag.

Burned bodies present several unique features.[76,77] Blood should be tested for carbon monoxide to ascertain whether the victim was breathing, i.e., was alive at the time the fire started. Soot or other combustion products in the lumen of the trachea also indicate active respiration while the fire was in progress. Borders and bases of blisters should be inspected for evidences of hyperemic vital reaction; true ante-mortem blisters contain fluid, not steam. Splitting of the skin, skull fractures due to expanding steam in the cranial cavity, and collections of coagulated blood in the extradural space should not be misinterpreted as due to ante-mortem injuries. Internal examination is often necessary to determine sex because incinerated male external genitals superficially resemble the vulva. Despite extensive external charring, many of the internal viscera will still be in condition to yield much information, and autopsy should proceed as far as possible along the usual lines.

## NEWBORN INFANTS

Infanticide and feticide laws differ considerably in various jurisdictions, but the principal questions will be: (1) What was the age of the fetus or infant, i.e., was it capable of independent existence? (2) Was the infant born alive? (3) Did it die by unnatural means?

External surface of the body is examined for evidences of washing or other postnatal care, injuries, ligatures around the neck, general degree of development, development of hair and nails, presence or absence of pupillary membrane, and maceration (indicating death in utero). Mouth should be inspected for foreign material such as newspaper or rags. Condition of the cord is noted with particular reference as to whether it has been cut, cut and tied, or merely torn. If the placenta is attached, it should be inspected for completeness and abnormalities; tissue blocks are saved. Weight of the placenta and length of the cord are recorded. Body weight and body length from crown to rump and from crown to heel should be accurately ascertained.

Internal examination should be complete in order to demonstrate all injuries or developmental anomalies which may be present.[13e, 26e, 78] The cranial vault is not opened by sawing but by cutting through the unossified fontanels and sutures

with scissors after the method of Beneke. A considerable amount of blood and edema fluid may be present in the soft tissues of the scalp and beneath the pericranium as a result of the birth process and should not be reported as evidences of infanticide. Unusual suture lines and natural cleavage lines may be confused with fractures of the skull. Tears in the falx or tentorium should be searched for before relations are disturbed. Intracranial hemorrhage must be interpreted with some caution, since, in our experience, varying amounts of subdural and subarachnoid hemorrhage are associated with a substantial number of natural births.

Abdominal incision should avoid the umbilicus in order to allow a complete inspection of the infantile circulatory system. Evidences of respiration are most important in judging whether or not the infant was born alive. Gross appearance of the lung may indicate expansion and aeration. The trachea, bronchi, and lungs as a unit are placed in a receptacle of water to see if they float. Each lung separately and then small pieces from different areas in turn are tested for buoyancy. The hydrostatic test is one of the oldest in legal medicine (Bartholin, 1663) but has limitations with which the examiner must be familiar. Air may enter the stomach during attempts at respiration and should be looked for. Examination of the stomach contents grossly and microscopically may indicate that the child has been fed.

The state of the epiphyses of the calcaneous, astralagus, cuboid bone, and lower end of the femur is determined as a further aid to the establishment of age.

The form and length of the medicolegal autopsy protocol will be influenced by local custom, but with the particular purposes and uses of this type of record in mind it is probably most satisfactory to omit unnecessary detail. Lengthy descriptions of normal or pathologic organs are interesting but, under the circumstances, unimportant conditions will necessitate much explanation to laymen and may actually confuse or obscure the important points. This is not to be taken as a suggestion that information be suppressed, which is something quite different from using judgment as to what appears in the written report of findings. The physician's notes may contain all the data, pertinent and otherwise, for future reference. We prefer to employ acceptable medical terminology in the protocol so that it will be understandable to other medical men. Explanations in nontechnical terms can be given to laymen when opinions are requested, or medical words and phrases can be explained in due course from the witness stand. Organs and lesions should be described in such a manner that, again, the description will be intelligible to other physicians. Diagnostic or all-inclusive terms are avoided, although we find it acceptable to describe normal organs as "normal." Negative findings may be mentioned briefly to indicate the extent and thoroughness of the examination and to show that all possibilities were kept in mind during the course of the autopsy. History is so important—and indeed many diagnoses cannot be made without it—that we incorporate in the preamble of the protocol the phrase: "From the anatomic findings and pertinent history I ascribe the cause of death to. . . ."

It is very advantageous to have two autopsy surgeons collaborate in cases which certainly will be controversial or which will involve much court work.

One physician should be in charge and may perform the autopsy, while the other observes and makes detailed notes. Two opinions are always valuable, and the alternate physician is available to testify in the event of illness or of conflict in schedules. Both participants should sign the report of autopsy findings.

The work of the autopsy surgeon will be subjected to more unfriendly scrutiny than is usual in medical life. Medical men may be retained for the purpose of discrediting the work or of finding flaws and weak points in the autopsy report. Nothing should be recorded or offered as fact which the examiner is not in a position to prove by means of anatomical, chemical, or physical means. Opinions or theories are not properly a part of the report of autopsy findings and when given subsequently should be designated as such. They then can be given importance and weight according to the knowledge and experience of the promulgator. In a famous trial for murder by poisoning, John Hunter[79] after some badgering was forced to say: "I do not mean to equivocate but when I tell the sentiments of my own mind, what I feel at the time, I can give nothing decisive." This is still a good rule both in and out of the courtroom; if you do not know, say so. Do not lessen your strength and reputation by becoming an advocate or partisan witness intent upon proving a preconceived opinion by distorting the facts.

Remember always that the same zeal and interest must apply to the elucidation of medicolegal problems as is shown by the honorable and conscientious physician in the more direct discharge of his obligations in the care of the sick. The burden of responsibility is no less great since without proper medical investigation crime will not be discovered, the lives of innocent persons may be ruined, material want and hardship may result for surviving families, reputations may be damaged by unjust allegations of suicide, epidemics of contagious disease will go undiscovered in the early phases when protective measures are most effective, and industrial hazards will go uncorrected because they are not pointed out. These greater objectives cannot be obtained merely by the perfunctory opening of a body to demonstrate any acceptable cause of death—or by hurriedly dismissing wounds and injuries as obvious after external inspection.

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# CHAPTER 3

# LEGAL AUTHORIZATION FOR AUTOPSY*

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There must be legal authorization for autopsy. If an autopsy is not validly authorized, those who order or perform it, or otherwise improperly participate in it, may be subject to liability, criminal or civil or both.

Provision has been made in all jurisdictions for authorization, by some public official or body, for autopsy in connection with deaths other than those due to natural causes.

Most commonly it is the coroner who is vested with the power, solely or in connection with an inquest, to investigate and to perform or to procure an autopsy in connection with deaths resulting from violence or casualty.

The general nature of the office of coroner has changed very little since the earliest days but, today, the coroner's authority and duties are defined by statute.

In a number of states the functions of the coroner are carried out by the justice of the peace; in others, there is provision that in certain circumstances the justice of the peace, or, rarely, the sheriff, shall act for the coroner; again, in a few jurisdictions, the office of medical examiner has replaced that of the coroner.

Specific statutes designate, as the source of authorization for autopsy, in connection with certain potentially criminal cases, various other officials, as the attorney general, the district attorney, the county attorney, the public health officer or the judges of certain courts.

It is important to realize that unless the coroner or medical examiner has legal jurisdiction over a body, he cannot give valid authorization for the performing of an autopsy upon it†; and that if an autopsy is wholly unauthorized and illegal, the coroner and all persons who assist in it are liable for the wrongful act.

Under Workmen's Compensation Acts, in a considerable number of states, there is provision for autopsy. In some states, there is statutory immunity when the autopsy is performed under the order of the Industrial Commission.

The courts of a number of states have recognized that a provision in an insurance policy giving the insurer the right of autopsy on the body of an assured is a reasonable one. Statutes, in a few states, require that such a provision be incorporated in a standard policy.

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†Larson v. Chase (Minn.), 50 N.W. 238, Darcy v. Presbyterian Hospital, 202 N. Y. 259.